SEEDS

The Energy Literacy Series

Teacher's Guide 5

SRA

SCIENCE RESEARCH ASSOCIATES (CANADA) LIMITED
Toronto, Montreal, Chicago, Palo Alto, Sydney, Henley-on-Thames, Paris

SEEDS 5

WRITING TEAM: Don Percival, Paul Gowans, Blair Nestransky, Jennifer O'Brien, Larry Pimm

REVISION TEAM: Donna Barge, Bernie Galbraith, Chris Jackson, Wayne Newbert

PROGRAM DIRECTOR: Hugh Phillips

SRA

EDITORIAL TEAM: Sylvia Hill, Sherry Henderson, Joe Sobura, Karin Velcheff

PRODUCTION COORDINATOR: Shelagh Roberts

DESIGN: Henning Christensen Graphics

ACKNOWLEDGEMENTS:

Every effort has been made to identify and credit appropriately the sources of all copyright material used in this book. Any information concerning perceived errors or omissions will be appreciated and the correct source acknowledged in subsequent editions.

Page 42 to 43 Adapted from *Oil and Gas — Their Origin, Production and Use,* (Canada, 1979) pp 24-25, with permission from Imperial Oil Limited.

Copyright © Society, Environment & Energy Development Studies Foundation, 1981.
Published by Science Research Associates (Canada) Limited.
All rights reserved. Printed in Canada.

No part of this publication may be reproduced or transmitted in any form, including any storage or retrieval system, or by any means, electronic, mechanical, photographic, or recording, without permission in writing from the publisher, except as granted at publication for specified pages.

Printing History

1 2 3 4 5 6 7 8 9 0 90 89 88 87 86 85 84 83 82 81

Reorder No. 3-280451 ISBN 0-574-09451-2

CONTENTS

Preface 4

Introduction 5

Energy Literacy Objectives 7

Activity 1 Energy: Its Many Forms 9
Activity 2 The Energy of Motion 13
Activity 3 Energy Can be Stored 16
Activity 4 Waterwheels, Windmills, and Turbines 19
Activity 5 From Coal to Kilowatts 21
Activity 6 Energy Flow in Food Chains 25
Activity 7 Balance of Nature 29
Activity 8 What Comes In and What Goes Out 32
Activity 9 How We Use Electricity at Home 35
Activity 10 How We Use Electricity at School 37
Activity 11 From the Well to the Car 39
Activity 12 Oil Refining and Our Environment 42
Activity 13 Our Plastic World 45
Activity 14 Oil: The Amount We Use 47
Activity 15 The Long and the Short of It 50
Activity 16 Use It If You Can 52
Activity 17 Decisions, Decisions, Decisions 54
Activity 18 Energy: How We Change It 55
Activity 19 Cracking the Code 57

Activity Sheets 58–68

Scripts for Sound Filmstrips
Energy: The Sun 69
Energy: How We Change It 70

PREFACE

"Because our society is geared to living from day to day, it is difficult to recognize the long-term significance of events that are happening now. Even on major issues, we expect immediate action from our leaders, and we generally limit our own participation to reading the headlines.

But, in the next twenty to fifty years, the world will undergo massive changes in its supply and use of energy. In order to cope, we will have to alter lifestyles and expectations. We must recognize, too, that the greatest changes will occur during our children's lifetimes, and beyond ours. We will be shirking our responsibility unless we do everything possible to prepare the next generation for these social changes.

Society must stop forming its opinions about energy from headlines only. We must learn, and teach, the facts and encourage the most careful analysis of the issues. Emotionalism can only deter society from effective action."

Marshall Williams

Marshall Williams is a director and past president of SEEDS, the non-profit foundation that he was instrumental in establishing in May 1976. The acronym SEEDS identifies both the organization — Society, Environment & Energy Development Studies Foundation — and its offspring, the curriculum project now reaching published form.

From its beginning, SEEDS has worked toward its primary goal — to encourage the development of an "energy-literate" society, a society concerned about and committed to the wise use of energy.

The first task undertaken was the coordination of available human and material resources for energy and environment education, with the objective of developing twelve levels of curriculum materials for elementary and secondary school use. To accomplish this task, sixty educators, teams of 5 working at each level, immersed themselves in the wide range of materials made available to them, sifting and organizing the topics and issues into meaningful units of classwork appropriate to students' level of growth and understanding. Then, 150 teachers, with prior in-service training, tried out the study modules with more than 4000 students during the 1978-79 school year. Concurrently, a formal evaluation of these pilot units was undertaken by a team of professors of education. This class-testing and evaluation, combined with information and reviews provided by educators and personnel from energy-related industries and government bodies, provided guidelines for additional teams of teachers who then revised the materials.

Throughout, with the involvement of educators, environmentalists, business people, industry consultants, and government representatives, we have tried to achieve the presentation of balanced and objective educational modules that will help young people develop informed views on energy and the environment and act on them.

Our first four years have been challenging, exciting, and rewarding. While there are many individuals to whom we extend our appreciation for helping to maintain this sense of purpose, one individual stands out as deserving of special thanks. Dr. Marshall Williams has been a constant source of leadership, encouragement, and most of all, vision.

Robert Westbury
Executive Director
SEEDS Foundation

INTRODUCTION

The SEEDS Curriculum Project, produced and published by SRA, provides both student and teacher materials for a four- to six-week unit of study on energy-related concepts. It is designed to help teachers incorporate this topical material into their regular social studies and science curricula by providing a "guided discovery" approach suited to the students' level of growth and understanding.

Information on both the SEEDS Foundation and the history of the SEEDS Curriculum Project is given in the Preface. This Introduction outlines the organization of the curriculum materials.

The components for this Level include:

- a Teacher's Guide in a SEEDS binder
- a Professional Reference Guide (to be published June 1981)
- a set of two sound filmstrips
- a 32-page Student Book

The **Teacher's Guide** provides information and guidelines, organized in a sequence of Activities, for presenting the topics and carrying out the experiments, discussions, and other investigations. A description of the key elements of each Activity follows.

STRUCTURE OF ACTIVITIES

Each Activity begins with a summary of practical details, set out to assist the teacher in planning and preparation. Following this summary appear some or all of the sections entitled Core Activity, Extension(s), Enrichment(s), and Teacher Background.

Core Activity

This section provides a suggested procedure for the Activity — whether it's a teacher presentation, an experiment, an audio-visual experience, or a discussion — to achieve the stated objectives.

Questions and Answers The questions embedded in the text or highlighted in boldface type are provided for you as a teaching aid, not as a script. Similarly, basic or possible answers (in whole or partial sentences) are provided when the progression of questions and answers is considered an integral part of the concept development. Two verbs in particular are used to maintain the "guided discovery" approach: When the verb *elicit* is used, it is assumed that students will have foreknowledge of the subject matter, either from an earlier activity or from their general knowledge; when the verb *speculate* is used, no previous knowledge is assumed and we suggest you have the students hypothesize, make informed guesses, or respond with the quite legitimate "I don't know." Do allow students adequate time, three or more seconds, to ponder before framing a response to these questions.

Experiments These are simple hands-on investigations of some of the basic concepts studied in this unit. They may be demonstrated by the teacher or carried out by the whole class. All materials are listed and should be readily available.

Use of Components Built into the procedure are suggestions for the appropriate introduction or use of the other components noted under the heading, Materials.

Extensions

This section provides a brief explanation or suggestion for one or more activities that will further develop the sub-topic and related social studies or science skills.

Enrichments

This section suggests activities that involve skills of other curriculum areas such as art, language arts, and music.

Teacher Background

Where a major or new concept is introduced, some background information is provided to reduce the need for teacher preparation. It usually takes the form of a brief summary of the basic scientific or technical concepts developed in the Activity or a sequence of one or two Activities. This section does contain more information than that given in the Student Books or the Activity Sheets. The Professional Reference Guide will contain still more extensive background information for the teacher.

Summary

Objectives The objectives are numbered sequentially from beginning to end of the unit, and are repeated for each Activity to which they pertain. This Level's objectives are summarized on page 7; a summary of the six-grade span of objectives will appear in the Professional Reference Guide.

Time Since the time allotted to science and social studies within the curriculum varies widely from district to district, we have indicated the probable time for each section of the Activity. The Core program will require four to six weeks, depending on how often you schedule science and social studies; the Extensions and Enrichments are not included in this estimate, although probable times are noted.

Because of the nature of the topics and experiments, some activities may take longer than the usual time you allot to a lesson. Some Activities, such as planting seeds, require preparations a few days in advance; these advance preparations are highlighted by a colored bar.

Vocabulary One aspect of "energy literacy" is the acquisition of the vocabulary with which to discuss concepts, topics, and issues. Of course, comprehension of the concepts is the ultimate goal, but the Activities themselves are designed to develop that comprehension.

The vocabulary lists and definitions are provided for your information and use at your discretion. It is preferable to provide a "handle" or name for a concept when the children themselves request it, having found new words necessary to describe the results of their experiments or the progress of their activities. However, the nature of the material sometimes requires that these words or definitions be introduced by the teacher. The vocabulary for each Activity is presented on two levels — "oral vocabulary" and "reading vocabulary." The **Oral Vocabulary** lists contain those words that the teacher is to present and define, that is, that require aural/oral comprehension. Definitions of these words are usually provided in the body of the teacher text. The **Reading Vocabulary** lists contain those words that the children will encounter in their books or on the Activity Sheets. The main reference for placing words in the reading list has been the text *Basic Elementary Reading Vocabulary*, by Albert J. Harris and Milton D. Jacobson (Macmillan, 1972). Words listed therein as at or above the level were entered as reading vocabulary. Other words not in this text but required by the nature of the program are, of course, included — first of all as aural/oral vocabulary, then as reading vocabulary. In both cases the inflections for variant forms also used in the Activity are noted in parentheses with the word.

Materials The items listed include other components for the level whether for student or teacher use. Special materials, not usually found in classrooms, are also listed.

Activity Sheets

Grouped at the end of this Teacher's Guide are the Activity Sheets which are designed to be used as black-line masters. On behalf of SEEDS Foundation, the copyright holder, SRA grants you, the teacher, the right to reproduce the Activity Sheets for classroom use. They are numbered sequentially and include a key to the Activity number and level. Where possible, answers are provided for you in the text of the Core Activity. In keeping with the spirit of "wise use" encouraged throughout this series, suggestions are frequently made for using the back surface of these sheets. An **Energy Folder**, as suggested at the end of the first Activity, can be prepared by the students for storing all the work they produce during this unit of study.

Sound Filmstrips

The scripts for the filmstrips required for this level are printed on pages 69–71. They are printed primarily as an aid to your preparation, a reminder of what you previewed or showed previously in class and so may vary slightly from the taped version. The cassette tape contains two recordings of the script, one for automatic advance of the frames (with an inaudible tone), one for manual advance (with an audible tone). When a section of a filmstrip would be helpful in introducing, reinforcing, or reviewing a concept, the frame numbers are noted in italics at the beginning of the Core Activity. The use of these frames is optional.

Student Book

The Student Book serves as a base of reference for the major topic presented in the level. It provides a focus of interest for some group or class discussions, and guidelines for experiments or activities. The colorful illustrations, whether photographic or artwork, have been selected to help students visualize and comprehend the more technical, complex, or unfamiliar elements of their study.

ENERGY LITERACY OBJECTIVES

The objectives, stated in terms of learning outcomes expected for the students, draw on energy-related concepts from the social sciences, the natural sciences, and the physical sciences.

1. Recognize people's need for energy sources
2. Recognize the sun's role in the formation of energy sources
3. Identify coal, oil, and natural gas as fossil fuels
4. Recognize that energy is used when change occurs, or when heat, light, or motion is observed
5. Recognize that heat, light, sound, motion, and electricity are forms of energy
6. Identify heat, light, sound, and motion as forms of energy
7. Recognize that kinetic energy can be transferred from one object to another
8. Deduce that kinetic energy depends on the speed and mass of an object
9. Recognize that energy can be stored and retrieved to perform work
10. Recognize that gravity can be used to do work
11. Deduce how height and mass are related to stored energy
12. Construct a model of a turbine wheel
13. Demonstrate that water converted to steam can do work
14. Classify electrical appliances according to the form of energy each produces
15. Recognize that electrical energy can be converted to heat, light, and mechanical energy
16. Identify the steps required to produce electricity from coal
17. Recognize that heat is dissipated into the environment in the conversion process
18. Identify the basic elements of a food chain
19. Examine the flow of energy through producers, consumers, and decomposers in a food chain
20. Define the term "balance of nature"
21. Identify some elements of one type of ecosystem and explain how they affect one another in maintaining the "balance of nature"
22. Identify major by-products of the fossil fuel-to-electricity energy-conversion process
23. Identify the effects of these by-products on the environment
24. Recognize electrical appliances as consumers of energy
25. Identify the major consumers of electricity in the home
26. Calculate the energy used by these consumers in kilowatt hours
27. Identify the major consumers of electricity in the school
28. Examine the steps required to produce gasoline from petroleum
29. List the main products of petroleum refining
30. Identify the environmentally harmful by-products of petroleum refining
31. Describe how this pollution can be prevented
32. Recognize that the burning of oil products is a major cause of pollution
33. Identify and classify petroleum-based products
34. Assess our dependence on fossil fuels to maintain our lifestyle
35. Recognize our current rate of petroleum consumption
36. Suggest ways of using energy derived from oil and other fossil fuels more wisely
37. Identify long and short conversion chains
38. Compare long and short conversion chains in terms of their energy use and effect on the environment
39. Deduce that shorter chains use less energy and produce less waste than long chains
40. Identify by-products from energy conversion processes
41. Identify uses for these by-products
42. Determine uses for other by-products
43. Identify possible effects on the environment of some processes used to convert energy from renewable and nonrenewable sources
44. Choose an appropriate course of action according to the analysis of a given situation
45. Recognize that we extend our energy conversion chains by using energy to manufacture consumer goods and process foods
46. Review and recall the major concepts presented in this module

Activity 1
Energy: Its Many Forms

OBJECTIVES

1. **Recognize people's need for energy sources.**
2. **Recognize the sun's role in the formation of energy sources.**
3. **Identify coal, oil, and natural gas as fossil fuels.**
4. **Recognize that energy is used when change occurs, or when heat, light, or motion is observed.**
5. **Recognize that heat, light, sound, motion, and electricity are forms of energy.**

Preparation Time
Core: 20 min
Enrichment: 10 min

Instruction Time
Core: 60 min
Enrichment: 30 min

Oral Vocabulary
crude oil, electricity, environment, natural gas

Reading Vocabulary
energy, forms of energy, fossil fuel, nonrenewable, renewable, source of energy

Materials
Each child will need:
- Student Book
- notebook / pencil

You will need:
- Filmstrip and cassette, *Energy: The Sun*
- projector / screen

TEACHER BACKGROUND

We depend on energy for everything we do — whether it's jogging around the playground, turning on the light, or taking the bus to school. But what is energy and where does it come from?

Energy is the name given to the ability to do work. No matter who or what does the work — people, animals, machines — energy is required.

Although energy is available from a variety of sources, nearly all these sources can be traced back to the sun — either directly, or through several links in the energy chain. The sun's energy travels about 149 000 000 km to our planet. Even so, we still feel its heat and see its light.

Energy that comes directly from the sun, solar energy, is often referred to as renewable energy because it is continuously being replenished. In the course of our lives and for as long as we can imagine, the sun won't burn out.

Wind, moving water, and biomass energy are other renewable sources of energy we will discuss in this activity.

Wind is really solar energy in the form of air in motion caused by the unequal heating of the earth by the sun. Wind can be used to turn windmills and propel sailboats.

The energy of water is linked to the sun through the water cycle. The sun heats water causing it to evaporate, or become a vapor. This vaporized water then rises, forms clouds, and eventually returns to the earth's surface in the form of rain or snow to start the cycle all over again. This cycle is responsible for the movement of water in our lakes and oceans. The energy of moving water is used to rotate waterwheels, move boats, and produce electricity.

Biomass energy is derived from things that were once alive. Living plants use sunlight to manufacture their own food, which in turn provides energy for the people and animals that eat the plants. The energy contained in some plants, such as trees, can also be used to produce heat by burning.

Some of our energy sources aren't as plentiful as the renewables. These are the nonrenewable sources, so called because their supply is finite. Once they're used up, they're gone for good. The fossil fuels — coal, oil, and natural gas — belong in this category. These energy sources were formed from the fossilized remains of prehistoric plants and animals, and the energy stored in them is directly linked to the sunshine of the distant past. Because fossil fuels took hundreds of millions of years to form, they will not be replenished in the foreseeable future.

Nonrenewable sources of energy account for more than three-quarters of our present energy supply. Oil provides most of the energy for transportation and home heating. Coal provides heat and power for industry. Natural gas is used to provide heat, to fuel stoves, and to power clothes dryers. Uranium, used in nuclear reactors, supplies heat to generate electricity in some areas.

CORE ACTIVITY

For children familiar with the SEEDS program, this opening activity with the filmstrip Energy: The Sun *is a review of topics they have covered in earlier grades. These children will know the vocabulary and the concepts denoted by them. Instead of a discussion on these concepts as they are introduced by the filmstrip, you might like to show the film twice. Show it the first time straight through with the narration as a general reminder of topics studied earlier. Then run it a second time without the narration, and call on individual children to supply the commentary.*

For children who are beginning the SEEDS program, this opening activity with the filmstrip Energy: The Sun *introduces them to the concepts of what energy is, the sources of energy used by society today, and the environmental and societal problems of our energy use, whether we use renewable or nonrenewable sources.*

Show filmstrip to frame 20. Discuss with children what they have learned about energy so far. The following questions will help to deepen their understanding of the concepts introduced. As reading vocabulary words come up, write them on the chalkboard.

How do we use energy?
To jump about, to run our cars, for example.

What does the sun do for us directly?
It gives us light, heat.

The sun's energy produces other kinds of energy. Can you name them?
Water, wind, and energy from plants.

How does the sun make rain?
The sun heats water until it turns to a vapor that rises into the air, becomes clouds, and falls.

How does the sun make wind?
It heats the earth's surface unevenly.

How does the sun help plants?
By giving heat and light for them to grow.

What is energy?
It is force, movement.

What does the narrator mean when she uses the expression source of energy?
Source means "the place or thing something comes from," so *source of energy* means "the place or thing we get our energy from." Heat and light energy can come from a wood source as well as from the sun. Wood is a stored source of energy; the sun's light on plants is a direct source of energy.

Before continuing with the filmstrip, sum up for the children that energy comes from different fuels. Food, the fuel for people's energy, comes from plants; plants get their energy to grow from the sun's light and heat; the sun is also the source of wind and water energy.

Continue with the filmstrip to the end and follow it with a discussion centered on the following questions.

Can you name three sources of energy which are renewable?
Sun, wind, and water.

Why are they called renewable?

Because they won't run out. They will always exist as long as the sun shines.

Can you name the three fossil fuels?

Coal, oil, natural gas.

Tell children that the oil we get out of the ground is called crude oil because we cannot use it in this form. It needs to be changed before we can use it.

Why do some people refer to fossil fuels as "buried sunshine?"

Because millions of years ago the sun shone on plants, some of which were eaten by the tiny animals then in existence. The fossil fuels we use today were once these plants and small creatures that when alive, were dependent on the sun.

How do people use the energy stored in fossil fuels?

All three fossil fuels can be used to make electricity, which is used to run machines to make things. Electricity also gives us heat and light. Oil and natural gas heat our homes, and oil (in the form of gasoline) runs our transportation system. In addition, oil and natural gas provide us with all the plastic items that are so much a part of our daily life.

Why are fossil fuels called a nonrenewable energy source?

Because once we use up fossil fuels, they are gone forever.

Tell children that fossil fuels help us to enjoy our modern way of life, but along with the benefits come problems.

What problems are created by our use of these fuels?

The use of fossil fuels creates problems for our environment, or surroundings; wildlife and plants are harmed when we extract fossil fuels, and our air and water can be poisoned when we use fossil fuels to make goods and to transport them.

Discuss with children why we should use our fossil fuels wisely. The points to stress here are that if we waste these fuels today, we'll run out of them sooner. We haven't yet developed our renewable sources sufficiently, or found new sources, to be able to use these as a substitute for the fossil fuels. If we reduce our current use of fossil fuels, we also reduce the harmful effects they have on our environment.

End the filmstrip discussion by asking children if they remember the filmstrip title – *Energy: The Sun*. Ask them why the filmstrip is so entitled. The reason, of course, is that whatever energy source we use, renewable or nonrenewable, the stored or harnessed energy came originally from the sun; so the sun is the main source of energy.

The filmstrip introduces children to what energy is. This module teaches that, for energy to be used, it must be converted, or changed. To begin this study, have the children turn to page 3 in their Student Books. Have them examine the pictues and read the text. After they have finished the reading, discuss it with them.

How can we tell that energy is being used?

When we notice heat, light, sound, or motion, or when we observe a change, we know that energy is being used.

Tell children that heat, light, sound, and motion are *forms of energy*. Write the phrase on the chalkboard. Tell children that energy comes in different forms; that there are many different kinds of energy.

Tell children to look at the picture of lightning on page 3. Elicit from them that there is electrical energy in lightning. We can see the change this energy makes when the sky lights up. Elicit from children that when we put food in a hot oven, heat energy heats up the food and cooks it; that when a light is turned on in a completely dark room, light energy enables us to see; that when the stereo is on too loud, sound energy causes our ears to hurt and the floor to shake; that when a dish is dropped on the floor, the energy of motion causes it to break. Make sure that children understand that heat, light, sound, and motion are forms of energy that cause changes we can observe. When the discussion is finished, have children copy the reading vocabulary words and phrases *energy, forms of energy, fossil fuel, nonrenewable, renewable, source of energy* into their notebooks.

ENRICHMENT

Art Make an Energy Folder In your next art class, have children make an energy folder for their Activity Sheets. To begin their folder, have them depict various sources of energy, as well as the forms of energy discussed in this activity (heat, light, motion, and electricity).

Activity 2
The Energy of Motion

OBJECTIVES

6. **Identify heat, light, sound, and motion as forms of energy.**
7. **Recognize that kinetic energy can be transferred from one object to another.**
8. **Deduce that kinetic energy depends on the speed and mass of an object.**

Preparation Time
Core: 20 min
Enrichment: varies

Instruction Time
Core: 45 min
Enrichment: varies

Oral Vocabulary
kinetic, linear, rotary, transferred

Reading Vocabulary
stationary

Materials
Each child will need:
- Student Book
- notebook / pencil

Each group will need:
- 2 tennis balls
- 1 hard rubber ball

You will need:
- 5 tennis balls
- 2 books

TEACHER BACKGROUND

Mechanical energy is the energy that is directly available for doing work through motion. Much of our technology is concerned with the conversion of other energy forms such as chemical, electrical, and heat, to the mechanical form. Machines, motors, and tools perform a large variety of useful and cumbersome tasks by transferring motion through gears and wheels or pushes and pulls. In this lesson, we will deal with one form of mechanical energy — kinetic energy or the energy of things that are moving. The motion may be in a straight line, circular, or to and fro.

CORE ACTIVITY

Introduce the lesson by telling children you want them to imagine they are in the country, quite alone, sitting in the middle of a large, grassy clearing surrounded by trees, bushes, a stream in the distance. Tell children their eyes are closed and their ears are covered. The weather is mild, slightly cloudy, and a light breeze is blowing. Have children relate to their sense of touch.

What can you feel?

The heat of the sun; less heat when a cloud passes in front of the sun (although with their eyes closed, they cannot see the cloud); the breeze blowing; and the coolness of the ground.

Elicit from children that they can feel the force (push) of the breeze, which indicates that the breeze is moving. State to the class that heat has to move as well. For example, if the sun is not obscured by a cloud we feel its heat. When the sun is hidden by a cloud, the amount of heat we feel is less. When the cloud has passed, we begin to feel the sun's heat reach us again. It takes time for the heat to get to us from the sun. The sun's heat is continuously moving toward us.

Now, tell children that in their imaginary scene they have just opened their eyes.

What things are moving?

Leaves moving on trees, animals, clouds moving across the sky, and the flowing water in the stream.

The final step children perform in this imaginary scene in the clearing is to uncover their ears.

What can you hear?

Stream gurgling, wind rustling leaves in trees, something moving in the bushes.

Tell children that if an animal were moving away from them, the sounds they would hear would get fainter. The sound becomes fainter because it has farther to travel.

Remind children that everything they have described as movement has energy. Tell children that this energy of motion is called kinetic energy. Although the emphasis is placed on motion, children have also reviewed other forms of energy — heat, light, and sound.

Have children turn to pages 4 and 5 in their Student Books and read the text and examine the pictures. Write the word *stationary* on the chalkboard. Ensure that the children understand its meaning. Have them read over the steps to part A of the experiment. Make sure that children understand the steps and that there is enough space available for them to do the experiment.

1. Divide the class into groups of four and distribute to each group: 2 tennis balls; 1 hard rubber ball. Tell the children to examine the balls. Elicit from children that both balls are round and are about the same size, but they have greatly different masses. Stress that although one ball is smooth and the other is fuzzy, this difference will not affect the outcome of the experiment.
2. Tell children to be sure that each group member tries the experiment. Then have children do part A and answer the questions in their notebooks. When children have completed part A, discuss the questions posed in their texts. These are some possible answers: **a)** The heavier ball needed more push, thus more energy, to keep it moving at the same speed as the lighter tennis ball. **b)** The ball moves faster as you throw harder. **c)** It's easier to catch the ball when it's moving slowly. **d)** The ball has more energy when it is moving faster. It is harder to stop. It has more energy because more energy has been used to make it move faster.

Elicit from children that before a ball moved, it had to be pushed; thus energy was needed to move the ball.

3. Demonstrate to children that a rolling ball exhibits two types of motion, rotary (in a circle) and linear (in a straight line), as it moves from one point to another on the floor. Children will feel this and see it as they follow your demonstration.
4. Have children read the steps to part B on page 5 of their Student Books. This experiment demonstrates that kinetic energy can be transferred from one object to another. Ensure that the children understand the steps and that each member of the group does the experiment. Have children do part B and answer the questions in their notebooks.

5. After they have completed the experiment, discuss the questions posed in their Student Books. These are some possible answers: a) After the hit, the stationary ball moved away. The energy the rolling ball had was transferred (or given) to the stationary ball. b) The stationary ball moved the least distance after it was hit by the rolling tennis ball. The stationary ball moved away at about the same speed as the rolling tennis ball because the masses of the two balls were the same. c) When the stationary ball was hit by the rolling rubber ball, the stationary ball moved away at a greater speed and moved farther. The rolling rubber ball had more energy than the rolling tennis ball because, although both balls were moving at the same speed, the rubber ball has greater mass and therefore greater energy.

To reinforce the concept of transfer of kinetic energy you will need: 5 tennis balls; 2 books. Set up the following demonstration.

1. Align four tennis balls in a row between the spines of two books.
2. Adjacent balls must be touching each other. Make sure that they do not fit too snugly.

Tell children to look at the picture on page 5 of their Student Book. Ask children to predict what will happen when the moving tennis ball collides with the row. Demonstrate the outcome. After collison, only the last ball in your row should move. The other balls should remain undisturbed. The energy of the moving ball will be transferred from ball to ball until it reaches the last one in the line.

The major points to stress at the conclusion of the activity are:
Energy is needed to move something.
The faster something moves, the more energy it has.
Energy of motion can be transferred from one object to another.
Energy of motion is related to the mass of an object. The heavier of two objects moving at the same speed will have more energy.

For the next activity, ask each child to bring a 20-cm length of string; a rubber band; a large safety pin; and an eraser.

ENRICHMENT

Art Have children cut out pictures from magazines and newspapers that show people and things moving. Children can then make a class collage to show how people use motion for leisure and work, and how people use machine-motion for work and transportation.

Activity 3
Energy Can Be Stored

OBJECTIVES

9. **Recognize that energy can be stored and retrieved to perform work.**
10. **Recognize that gravity can be used to do work.**
11. **Deduce how height and mass are related to stored energy.**

Preparation Time
Core: 25 min
Extension: varies

Instruction Time
Core: 45 min
Extension: 60 min

Oral Vocabulary
mechanical, potential

Reading Vocabulary
gravity

Materials
Each child will need:
- Student Book
- notebook / pencil
- 20-cm length of string
- safety pin
- elastic band
- eraser

TEACHER BACKGROUND

In the previous lesson, we examined the energy of motion or kinetic energy. This lesson examines potential energy — the energy of objects that are not moving but have the potential of moving and doing work. In mechanical systems, potential energy may result from the condition or the position of an object.

To illustrate how potential energy may arise from the condition of an object, consider a small toy automobile operated by a spring. As you wind up the toy, you do work — use energy — to compress the spring. Your energy is now stored in the compressed spring. When you release the toy, the spring unwinds and releases the stored energy. This stored energy is now converted to kinetic energy and the toy automobile runs until the spring returns to its original shape. The use of materials with elastic properties is one means of storing mechanical energy.

Potential energy also results from the position of an object. Consider a book resting on the floor. It can't move or do anything. When you raise the book a certain distance from the floor, you do work, that is, use energy, against the force of gravity. While you hold the book, the energy you put into raising it is stored by virtue of the book's position relative to the floor. The book is now in a state to move and do work. When you release the book and it falls, the potential energy changes to kinetic energy.

CORE ACTIVITY

Elicit from the class the four major points stressed in the previous activity. As each one is stated, write it on the chalkboard: *Energy is needed to move something; The faster something moves, the more energy it has; Energy of motion can be transferred from one object to another; The heavier of two objects that are moving at the same speed will have more energy.*

Tell children that when people or machines use pushes or pulls to move something a certain distance, the people or machines do work. Remind children that they had to push their tennis ball to get it to move. They supplied the energy and thus did work. The type of energy which is used for doing work through motion is called mechanical energy. Elicit from children that once the tennis ball was rolling it had energy of motion. Remind children that another name for the energy of motion is kinetic energy. Tell children that kinetic energy is one part of mechanical energy.

Tell children to turn to page 6 in their Student Books. Tell them that the photographs on this page show examples of kinetic energy — the energy of motion.

Before children read the text on page 6, write the word *gravity* on the chalkboard. Tell children that we experience gravity every day. The earth pulls us and all objects toward its center. Thus things "fall down." This force which pulls us down toward the earth's center is gravity. Have children read page 6. Then tell them that this "falling down" in the waterfall and the roller coaster is caused by gravity.

Tell children that although things have energy when they are moving, they can also have energy when they are not moving — energy can be stored and then released. They are now going to do some simple experiments to see how this can be done.

1. Tell children to take their piece of string and tie one end around the middle of a pencil. Have the class hold the string so that the pencil is hanging in the air. Tell them to twist the pencil two full turns, hold the pencil in this position for a second or two, and then release the pencil. Have them repeat these steps using five, then ten turns of the pencil.

2. When everyone has finished, ask the class to describe what happened. Elicit responses that emphasize the following observations. Once you release the pencil, it spins back to its original position. You had to release it before it moved. When you increase the number of twists, you are putting more energy in, and the pencil spins back faster and takes longer to return to rest.

3. Now tell the children to take their elastic bands and stretch them to different lengths, hold them for several seconds, and release them at one end. Elicit from children that the energy they put into twisting the pencil and stretching the elastic band did not just disappear. This energy was stored in the twisted string or the stretched elastic band, ready to be released. It was available to do work. Once the pencil or elastic band was released, the stored energy was changed to kinetic energy.

4. Tell children to examine the safety pin and open and close it a few times. Explain that the coiled end is a simple spring. The spring can store energy too. In this case, the energy we put into moving the free end of the pin behind its protective cap is stored in the coil. The protective cap keeps the pin locked in place and the energy from being released. Elicit from children the other possible uses of springs, such as: wind-up toys; jack-in-the-boxes; wind-up watches; retractable ball-point pens; spring mechanisms on self-closing doors, in doorlocks; shock absorbers in cars, jets; paper clips; spring washers; spring balances.

5. Tell children to place the safety pin and a book on the floor near their desks. Elicit from children that the safety pin and the book are not moving, are not able to move, and cannot do work.

6. Tell children to place the safety pin and the book on their desks. Elicit from them that now the safety pin and book are not moving, but that they could move (fall off the desk) and therefore are capable of doing work.

If children have not grasped the concept and respond that the safety pin and the book are still unable to move and do work, have them push the pin and the book off a desk. Elicit from children the responses that the safety pin and book were able to move when they were on the desk and that they were able to do work because of their position above the floor.

Have children turn to page 7 in their Student Books and answer the first 3 questions in their notebooks. Then they can proceed independently with the second part of the experiment. After children have completed the exercises, discuss the answers to the questions. **1.** The book and safety pin could sit on the desk forever if they were not pushed off. **2.** The book and the safety pin have stored energy when they are sitting on the desk. **3.** The book has more stored energy because it has more mass. **4.** The eraser had stored energy before it was let go. **5.** The eraser had the most speed in the middle of its swing. **6.** It had kinetic energy. **7.** The eraser rose to the same level that it had started at.

Tell children that this shows that we got back the same amount of energy that we put into raising the eraser. Air resistance slows down the eraser as it continues to swing. **8.** In the beginning (A) and at the end of its swing (C) the eraser had stored energy. In the middle (B) it had kinetic energy. **9.** The eraser had more energy when it was moved farther out to one side. **10.** You could see this when the eraser moved faster and went higher. **11.** The eraser is like the roller coaster because the roller coaster has stored energy at the top of a hill. At the bottom of the hill the roller coaster has only kinetic energy. The higher the hill is, the faster the roller coaster moves and the farther it goes.

At the conclusion of this activity define the term potential energy. Tell children that whenever an object is not moving but is able to move, the object has stored energy. Another name for *stored energy* is "potential energy." Stress the following points:

Potential energy can exist in certain kinds of objects such as springs and elastics.
We can use gravity to store energy. Potential energy from gravity depends on the position of an object.
The heavier an object is and the farther the distance it has to fall, the more potential energy it has.

EXTENSION

Waterfalls of the World Have children go to the library and collect data on the height, volume flow, and location of five to ten waterfalls from anywhere in the world. On a class chart, have children draw each waterfall's height to scale. Have them also draw the width of each waterfall to scale. Children can summarize their information under each drawing. The following list of waterfalls will get them started: Angel Falls, Venezuela; Tugela Falls, South Africa; Yosemite, United States; Wollomombi, Australia; Gavarnie, France; Takakkaw, Canada; Staubbach, Switzerland; Vettis, Norway.

Activity 4
Waterwheels, Windmills, and Turbines

OBJECTIVES

12. **Construct a model of a turbine wheel.**
13. **Demonstrate that water converted to steam can do work.**

Preparation Time
Core: 30 min

Instruction Time
Core: 60 min

Oral Vocabulary
convert(er)(ing)(ion), hydroelectric

Reading Vocabulary
produce, turbine

Materials
Each child will need:
- Student Book
- notebook / pencil

Each group will need:
- Activity Sheet 1
- 1 aluminum pie plate (at least 10 cm in diameter)
- 1 pair of scissors
- 1 paper clip
- 1 pencil
- 1 plastic drinking straw
- 1 aluminum tray
- 1 metal nail
- 1 foam cup
- masking tape

You will need:
- 1 electric kettle
- aluminum foil
- masking tape
- Filmstrip and cassette, *Energy: How We Change It* (optional)
- projector / screen

CORE ACTIVITY

Filmstrip Energy: How We Change It, *frames 6 to 12, may be used to* introduce *this activity.*

Remind children that before we can use energy, we need to change it to a form we can control. Tell them that there is an enormous amount of electrical energy in a lightning bolt, but we cannot use this electricity to run a television set because we cannot control it.

Tell them that one way we can get electricity that we can control is to build a dam and hydroelectric station near a river. The term *hydro* means "having to do with water." So a hydroelectric station uses water power to make electricity. Elicit from children that building a dam is a way of controlling water energy.

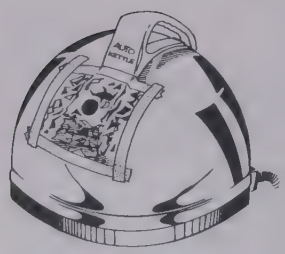
Remind children of the picture of the waterfall on page 6 in their Student Books. Elicit that dams can be built and water can be stored in large lakes behind the dams. This water can be used when needed. The level of water in the lakes can be controlled during dry seasons as well as flood seasons. Elicit from children that water power is a renewable source of energy.

In the power station, the energy of the falling water is changed to electricity. Tell children that when we change energy to a form we can control we are converting the energy from one form to another. The engines that we use to make this change are called energy converters. Tell them that energy conversions are what make our modern way of life possible.

Tell children that they are now going to investigate an energy converter — a simple engine called a turbine. Write the words *turbine* and *produce* on the chalkboard and ensure that children understand their meanings and can read and pronounce them.

Have children turn to page 8 of their Student Books and read "Waterwheels, Windmills, and Turbines." Allow everyone time to finish the reading. Elicit that a turbine is a wheel with blades that is joined to a shaft. Tell children that turbines are an important part of the machinery we use to make electricity. Tell them that they will now make their own model turbine and experiment with different ways of making it turn.

1. Divide the class into groups of two and provide each group with: 1 aluminum pie plate at least 10 cm in diameter; 1 pair scissors; 1 paper clip; 1 pencil; 1 plastic drinking straw; 1 metal nail; masking tape; 1 aluminum tray; 1 foam cup; Activity Sheet 1.
2. Have children read the instructions on pages 8 and 9 in their Student Books. Go over each step with children to make sure they understand the procedure.
3. Provide help as children make their model turbine. It is important to check to see that the shaft fits snugly in the hole in the pie plate. You may need to glue the shaft to the pie plate. The wheel should not rotate around the shaft.
4. When the children have finished their turbines, tell them to follow the instructions for conducting the experiments in their Student Books and record the answers to the questions in their notebooks.
5. For part C, "The Steam Turbine," cover the spout of an electric kettle with a piece of aluminum foil. Tape the foil to the kettle on the bottom and up both sides. Poke a pencil hole in the foil as near to the tip of the spout as possible. You should supervise the kettle at all times to make sure that no one gets burned.



When everyone has finished, discuss the answers to the questions posed in the Student Book. **A The Windmill 1.** The windmill spins gently when you blow on it lightly. **2.** The windmill spins more quickly when you blow harder. You supply more energy when you blow harder. **B The Waterwheel 1.** Yes, the water has stored energy. **2.** When the water strikes the blades of the turbine, the turbine spins. **3.** To make the wheel turn the fastest, you should hold it as far away from the cup as possible because the farther the water has to fall, the more energy it has. **C The Steam Turbine 1.** The turbine turned as the steam hit it. **2.** The steam was produced by boiling the water in a kettle.

Stress that the turbine wheel caused a change in the direction of the energy of motion. The wind, water, and steam moved in a straight line until they hit the blades of the turbine. Then the turbine moved in a circle. Elicit that because the turbine wheel caused a change, we can call it an energy converter.

For the next activity, ask children to prepare a written list of five appliances that use electricity that they can find in their homes.

Activity 5
From Coal to Kilowatts

OBJECTIVES

14. **Classify electrical appliances according to the form of energy each produces.**
15. **Recognize that electrical energy can be converted to heat, light, and mechanical energy.**
16. **Identify the steps required to produce electricity from coal.**
17. **Recognize that heat is dissipated into the environment in the conversion process.**

Preparation Time
Core: 20 min
Extensions: varies

Instruction Time
Core: 60 min
Extensions: varies

Oral Vocabulary
energy conversion chain

Reading Vocabulary
efficient, extracted, generate(or)(ing), hauler(s), kilowatts, process

Materials
Each child will need:
- Student Book
- Activity Sheet 2
- notebook / pencil

You will need:
- Filmstrip and cassette, *Energy: How We Change It* (optional)
- projector / screen

TEACHER BACKGROUND

Heat is the lowest form of energy. All other forms of energy are eventually converted to heat. Light strikes a window pane: the glass warms up. Running machine parts rub against each other (friction); this friction produces heat. An electric current passes through a wire; the wire heats up. We can convert heat energy to one of the higher forms of energy, but only at a considerable cost in terms of energy loss. Consider the generation of electricity using coal. Refer to the "Coal to Kilowatts" diagram on pages 10–11 of Student Book.

Because of its chemical structure, coal contains a certain amount of stored energy. When we burn coal, its chemical structure is altered. Carbon dioxide and water are formed and heat energy is released. This heat energy is used to convert the water in the boiler to steam. The steam passes through a turbine causing the turbine blades to turn. The shaft holding the blades spins the generator that produces electricity.

Not all of the heat generated in the boiler is used for the water-to-steam conversion. Some escapes up the smokestack. Additional heat energy is lost to the air around the turbines and generator. Heat is transferred to the water used for condensing the steam. Some heat is also lost from the power lines during transmission.

The overall efficiency of the coal-to-electricity conversion is about 40%. About 60% of the energy initially present in coal is lost to the environment in the form of low grade heat during the conversion process. When we consider the additional steps of extraction and transportation of coal and the final use of the electricity, the energy loss is even greater. Heat energy is also lost when oil or natural gas is used to generate electricity.

CORE ACTIVITY

Filmstrip Energy: How We Change It, *frames 15 to 21, may be used at the end of this activity to* review *the concepts introduced.*

Ask several children to read aloud the list of appliances they have prepared. As the children read their lists, write the items mentioned on the chalkboard until you have about ten different items. Elicit from children that the appliances use electricity and that they must be plugged in or switched on to make them work.

Tell children that each appliance changes electricity to some other form of energy. For example, a kettle changes electricity to heat energy. We call something that changes energy from one form to another an energy converter.

Draw three columns on the chalkboard with the following headings: *Mechanical(M), Heat(H), Light(L).* With the class, classify each appliance according to the form of energy it produces. Here is a sample chart.

Mechanical(M)	Heat (H)	Light(L)
blender clock (with moving hands) egg-beater can opener vacuum cleaner fan washer refrigerator (motor-pump)	clothes dryer(M) frying pan coffee maker hair dryer(M) toaster(L) kettle electric heater(L) stove(L)	lightbulb television (also sound-M) digital clock

As you can see in the above chart, some appliances convert electricity to more than one energy form. For example, a clothes dryer produces heat and motion and a television produces both light and sound. After the chart is completed, have children copy it in their notebooks.

Tell children that most appliances do not use all of the energy they produce for the job they do. For example, if we come close to a kettle boiling water, we can feel heat given off to the air. This heat does not do any useful job other than warming the air. Most appliances that change electricity to another form of energy give off heat to the air that is not used.

Where does electricity come from?

Wall socket, wires, power lines, power station.

How can we make electricity?

Water power.

Speculate with children about other ways to make electricity. Other alternatives include coal, oil, natural gas, and nuclear power.

Write the reading vocabulary words on the chalkboard. Explain that *generate* means "to make;" that a *generator* is a "machine that generates or makes electricity;" that a *kilowatt* is the name of the unit used to measure electricity; that a *hauler* is a type of truck; that something is *efficient* if it does not waste anything; and, that a set of actions or changes that take place in a certain order is called a *process*. Ensure that children understand the meaning of each word and can read and pronounce each one.

Have children turn to pages 10 and 11 in their Student Books. Tell them that this activity will describe how coal can be converted to electricity. As they read the text and examine the "From Coal to Kilowatts" diagram, discuss the following points with the class. We need to use coal to generate electricity because, in some places, we cannot use water power to make electricity. In these places, there may be no rivers or the rivers may not be large enough. Coal has stored energy that is ready to be released. When we burn coal, its stored energy is released as heat.

Guide the children through the steps in "From Coal to Kilowatts" by eliciting that coal is crushed into a fine powder and mixed with air so that it can be

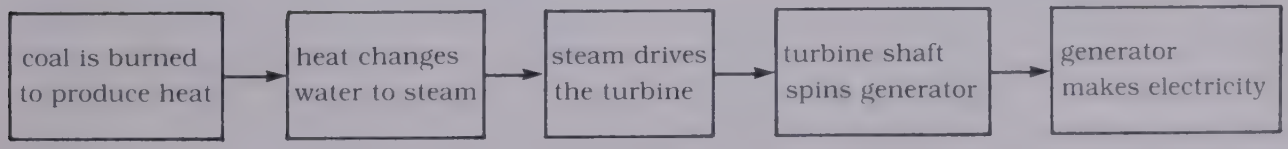
set on fire much more easily. The burning coal heats the water to produce steam. The steam turns the turbine. The turbine shaft turns the generator. The generator spins and makes electricity. After the steam passes through the turbine, it is cooled and changes back to water. This water goes back to the boiler. The water that cools the steam goes to a cooling pond and then to a nearby lake or river.

Direct children to the diagram of the generating station. Elicit from them where heat energy may be lost or wasted during the process of converting coal to electricity. If the children do not respond, tell them that not all of the heat energy produced by burning the coal is used to generate electricity. Some heat is lost from around the boiler and goes up the smokestack. The pipes that carry steam to the turbine are very hot, and they give off heat to the surrounding air. Both the turbine and generator get very hot as they spin. This heat is given off to the air. Even the power lines that carry electricity give off some heat energy. Also, the water used to cool the steam becomes hot too. Heat energy is lost to the air and surroundings in the cooling pond. Warm water from the cooling pond is pumped back to the lake. All this heat energy is not used for anything. So, we say it is "lost." Only about 40% of the energy stored in coal ends up as electricity. Because so much heat energy is lost or wasted, this process is not an efficient way of making electricity.

Have children answer the questions on page 11 of the Student Book in their notebooks. These are possible answers: **1.** Haulers or huge dump trucks. **2.** No. It is crushed to smaller pieces, cleaned, and stored in piles. **3.** To a huge bin. **4.** The coal is crushed to a fine powder. **5.** It is mixed with air. **6.** It catches fire. **7.** The fire heats the water. The water changes to steam. **8.** The steam makes the blades and shaft spin. **9.** It turns the generator. **10.** It makes (generates) electricity. **11.** It is changed back to water. Cold water from a nearby lake or river cools the steam. **12.** It is not efficient. It is wasteful.

Hand out Activity Sheet 2. Make sure that children understand the method and format of the Activity Sheet. When children have completed their sheets, have them correct their answers using their Student Books as reference.

Tell children that when one form of energy is changed to another form, it is a type of process called an energy conversion. The whole process of changing coal to electricity is called an energy conversion chain. It is known as a chain because each energy conversion step is linked to the following step to produce the electricity. Review the basic energy conversion steps used to convert coal to electricity. As you describe the process, draw the following flow chart on the chalkboard. Leave space on the left side of the chart.


coal is burned to produce heat
heat changes water to steam
steam drives the turbine
turbine shaft spins generator
generator makes electricity

Elicit from children that before coal can be used at the plant, it must be extracted, or taken out of the ground, and shipped there. Add two more boxes to the left of the diagram to indicate these steps. Tell children to copy the diagram on the back of Activity Sheet 2 and file the completed Activity Sheet in their energy folder.

Tell children that the same steps are followed when oil, natural gas, or nuclear power is used to make heat to generate electricity. Elicit from children that heat energy will also be lost when oil, natural gas, or nuclear power is used, and that coal, oil, natural gas, and nuclear power are nonrenewable energy sources.

Remind children of their experiments with their turbines. Have them speculate about which steps are unnecessary in the energy conversion chain when we generate electricity using water power. The energy of moving water turns the turbine. Water power is converted directly to mechanical energy at the turbine step.

EXTENSIONS

Locating Power Plants Each child will need: 1 area resource map; 1 map showing location and nature of power generating stations.

Distribute an area resource map to each child. Ask children to predict the locations of thermal generating plants and hydroelectric stations, given the locations of the resources in the area. Hand out the maps showing the actual locations of the plants and have children compare the real sites to their predictions. Discuss possible reasons why the plants were located where they were.

Inside the Plant Take children on a field trip to a power generating plant. The plant may be a fossil fuel generating station or a nuclear power plant.

Activity 6
Energy Flow in Food Chains

OBJECTIVES

18. **Identify the basic elements of a food chain.**
19. **Examine the flow of energy through producers, consumers, and decomposers in a food chain.**

Preparation Time
Core: 20 min
Extension: 10 min
Enrichment: 20 min

Instruction Time
Core: 60 min
Extension: 30 min
Enrichment: 60 min

Oral Vocabulary
carbon dioxide, chemical energy, nutrient

Reading Vocabulary
consumer(s), decomposer(s), producer(s), pyramid

Materials
Each child will need:
- Student Book
- Activity Sheet 3
- Activity Sheet 2 (completed)
- notebook/pencil

TEACHER BACKGROUND

An ecosystem is a community of plants and animals that interact with one another and with their environment. None of these organisms is capable of surviving on its own. They are mutually dependent on one another and their environment.

Plants and animals rely on energy in the form of food to carry on their life processes. Some organisms produce their own food (producers), while others (consumers) rely for their food on producers or other consumers that originally obtained their energy from producers. A food chain is a simplified pattern showing which organisms feed on which other organisms.

Let's look at a specific example of a food chain. In a field, green plants are eaten by meadow mice, which in turn are preyed upon by hawks. The green plants are producers. They convert the light energy from the sun, water, carbon dioxide, and soil nutrients into food. This is a chemical conversion called photosynthesis — "putting together by means of light." Meadow mice are consumers of this food and because they feed directly on producers, they're called first-order consumers. They are also called herbivores, because their diet is mainly vegetable matter. The hawks, which eat the mice, are second-order consumers. They are carnivores because their diet consists mainly of the flesh of other animals.

Ultimately, the plants and meadow mice that survive being eaten, die, as do the predatory hawks. When this happens, microscopic organisms break down their remains, freeing the raw materials to be used again by the food producers and so the cycle continues. These organisms of decay are consumers, but because of their specialized role in the recycling of nature, they're referred to as decomposers.

Food chains show us which organisms feed on which other organisms, but sometimes it's important to know how much is eaten. In terms of the simple plant-meadow mouse-hawk chain, there must be more plants in the field than the meadow mice can consume or all green life would be destroyed. There must also be more mice than would be eaten by hawks, or there wouldn't be any more mice. A pyramid of numbers shows the quantity of plants and animals interrelated in a food chain. In our example, the pyramid has a broad base of vegetation on the bottom, a narrower level of mice in the middle and hawks at the apex.

But the pyramid is more than a quantitative representation of organisms in a food chain. It portrays a chain of events involving the capture of solar energy by the producer plants and gradual subsequent loss of energy as the conversion chain proceeds from the producer to the top carnivore. This energy loss is a biomass loss. Biomass is the energy from living things. There is a great deal more biomass in the plants at the base of the pyramid than there is in the hawk at the top. This biomass loss represents the energy used for respiration, growth, body maintenance, and reproduction, which is eventually dissipated to the environment as heat. Food chain conversions, like all conversions, lose energy in the conversion process.

CORE ACTIVITY

Introduce this activity by reviewing with children some of the energy conversion chains with which they are familiar. Elicit from children that the longest chain they've noted is the one that begins with fossil fuels, whose origin was plant and animal life that existed on earth hundreds of millions of years ago. Tell children that food, which is the fuel that gives energy to all living things, has conversion chains similar to the fuel chains people have developed to produce electricity. Some food chains are long, some short. Demonstrate by using *milk* as an example of a food that gives people energy. Ask children to tell you its original source, but don't let them stop with the cow; the cow needed food in the form of grass to make milk. Guide children to supply the following chain: grass or plants → cow → milk. List other foods that animals or people eat on the chalkboard and have children trace food energy to its source. Add lines as you elicit each link in the chain. When the chain is completed, add arrowheads from the plant to the end of the chain. The following are some examples of possible food chains you may wish to use.

plants (fresh or saltwater) → insects → fish
plants → rabbits → wolves
plants → mice → hawks
plants → mice → snakes
plants → insects → toads
plants → insects → toads → snakes → hawks

Elicit from children that the food chains they have given all begin with plant life. Ask where the plant gets its energy to grow. Answers should include soil, air, water, and sunlight. Point out that soil contains water and chemicals called nutrients that plants can use to make their food. The air contains a gas called carbon dioxide that plants also need to make their food. Stress that it is the light energy from the sun that makes plants able to change the water and nutrients in the soil and the carbon dioxide in the air into food for growth. The plant converts light energy from the sun into chemical energy for growth. Thus, the energy source of all food chains is light energy from the sun.

End the discussion by writing these words on the chalkboard: *producer, consumer, decomposer.* Ask children what they think "producer" means. Elicit that producers "make something." State that plants are considered producers of food for all living things. Ask children what "consumer" means. If no one knows, state that consumers are those living creatures that obtain their food from producers. Remind children of the food chains they developed for you earlier and show how consumers eat consumers lower down in the food chain. The plant → hawk chain is particularly relevant here. Ask what "decomposer" means. If no one knows, state that decomposers are a special kind of consumer. They break down the bodies of living things when they die, releasing important nutrients to the soil.

Why are decomposers important in the food chain?

Because they break down dead things releasing nutrients so that plants can use them to make food.

Speculate with class on what the world would be like if we didn't have decomposers.

Have children turn to the food chain shown on page 13 of their Student Books.

What happens when the sun shines on plants?

Plants use energy from sunlight to make food.

What happens when the cricket eats the plant?

The cricket (plant-eater) receives energy from the plant.

What happens when a toad eats a cricket?

The toad (meat-eater) receives energy from the cricket (plant-eater).

In each of these steps, is the energy from the sun being changed?

Yes. It is being converted, first to a plant, then to a plant-eating animal, and then to a meat-eating animal.

Elicit from children that a food chain is an energy conversion chain. Tell class that some energy is lost when it is converted from one form to another.

Have children speculate on how energy is lost in the food chain. Guide them to understand that some of the energy given by food is used for growth, some is used for breathing, some is used for keeping warm, some is used for reproduction, and some becomes body waste.

Write the word *pyramid* on the chalkboard. Explain that a shape that is bigger at the bottom than it is at the top is called a pyramid. Have children turn to the illustration of the pyramid of numbers on page 13 of their Student Books. Tell children that this pyramid shows how energy is lost through conversion. The plants form the base of the pyramid. They far outnumber the crickets in the middle. The crickets in turn outnumber the toads at the top.

How does this pyramid show energy losses?

Because it takes so many plants (producers) at the bottom to feed one toad (consumer) at the top.

Hand out Activity Sheet 3. Have children write their answers in their notebooks or on the backs of their sheets for the questions posed on page 13 of their Student Books. Possible answers for the questions on page 13 are: **1.** A producer makes something. Plants are producers. A consumer is an animal that eats producers or eats other consumers that have eaten producers. A food chain is an energy conversion chain. It shows how light energy from the sun is converted to plants and then animals. **2.** All living things need food to live. It gives them energy. **3.** Each member of the food chain eats the one before it for food. **4.** Many food chains can be given as an example. **5.** When one member of the food chain eats another member, it gets energy to live and grow. **6.** A decomposer breaks down the bodies of living things when they die. **7.** When decomposers break down the bodies of animals and plants, nutrients are added to the soil. Plants can use these nutrients to make their food. **8.** The pyramid of numbers represents the energy lost in conversion.

To review the concept of food chains, have children complete the chains on Activity Sheet 3 by filling in the words given in the right order. Then, go over the Activity Sheets with children to ensure that they have filled in the food chains correctly. Have children file them in their energy folders. The answers for Activity Sheet 3 are: **Food Chain One**–sun, grass, grasshopper, crow, decomposers. **Food Chain Two**–sun, willow shoots, snowshoe rabbit, wolf, decomposers.

Have children turn back to their copy of the energy conversion chain in Activity 5, which they drew on the back of Activity Sheet 2, "From Coal to Kilowatts." Ask them what steps they should add to this chain so that it starts at the beginning (sun shines → plants grow → plants die, coal formed). Put these steps on the chalkboard and have children add them to their copies. Have children return Activity Sheet 2 to their energy folders.

EXTENSION

Food Chain Field Trip Take children on a short field trip to the school yard.

Identify producers and consumers in this environment. Discuss these producers and consumers, using questions similar to the following: What are the living things we can find here? What are the producers or "makers" of food? What are the consumers or "takers" of food?

You may want to record the classroom results in chart form. Other examples of ecosystems that may be investigated are a classroom aquarium, ecosystem bottle, local park, or ravine.

ENRICHMENT

Art Each child will need: nature magazines; scissors; paste; string; hangers for mobile; construction paper. Have children illustrate a simple food chain in the form of a collage using pictures from nature magazines. Or have children make food chain mobiles. Have them make a picture of the sun and hang several plant pictures from it. From these plants, hang a few animals, including people.

Activity 7
Balance of Nature

OBJECTIVES

20. **Define the term "balance of nature."**
21. **Identify some elements of one type of ecosystem and explain how they affect one another in maintaining the "balance of nature."**

Preparation Time
Core: 20 min
Extension: 10 min
Enrichment: varies

Instruction Time
Core: 60 min
Extension: 30 min
Enrichment: varies

Oral Vocabulary
balance of nature

Reading Vocabulary
none

Materials
You will need:
- 400–500 g package of sunflower seeds
- brown paper bags for two-thirds of class
- green sashes for two-thirds of class
- brown sashes for one-third of class
- red sashes for one-third of class

TEACHER BACKGROUND

All parts of the environment are connected to one another and depend on one another in order for life to be maintained on our planet. These include the sun, plants, animals, water, soil, and air. The intricate network formed by the interrelationships of these components of our biosphere (the part of our world in which life exists) can be called the web of life.

The web consists of several different levels of organization, many overlapping, many forming complex relationships between living and nonliving matter. Although the connections may appear haphazard in various areas of the web, there is a definite order to the overall picture.

Food chains and webs have a built-in system of checks and balances. For example, if for some reason, field mice multiply too rapidly, their numbers will be controlled by predatory hawks. Unfortunately human beings often disturb this natural balance.

Industrial pollution, for example, can result in the death of hawks, resulting in an increase in mice harmful to local crops. Nature's ecosystems are fine-tuned and our abuse of any link of a food chain has a dramatic effect on the entire chain.

Our planet has an automatic self-renewing natural environment of water, air, and soil. Evolving over billions of years of earth's history, the environment is perfectly balanced with the plants and animals that inhabit it. It can keep itself going indefinitely, providing this delicate balance is not abused and providing that the sun continues to shine.

CORE ACTIVITY

Tell children that they are going to play a game in which they will assume the roles of animals in a specific food chain. Remind them of the last activity on food chains, particularly the part on the pyramid of numbers. Discuss with children, using questions similar to the following:

Which part of the pyramid of numbers is the biggest?
The bottom where the producers, plants, exist.
How does the pyramid build from there?
With each level of consumer, the pyramid gets smaller.

Elicit from children that as the food pyramid or chain moves further and further from the producer at its base, the number of consumers becomes smaller.

Game A Tell children that they will be divided into three equal groups. One group will represent grasshoppers, one group thrushes, and one group hawks.

Ask children whether these animals are producers or consumers. Tell them that sunflower seeds will represent producers, the green plants. If some child asks why the groups are equal when we know that, according to the pyramid of numbers they can't be, tell the child that the purpose of the game is to show this fact.

Give each grasshopper a green sash to wear for identification and a small brown paper bag to put the sunflower seeds in. Tell grasshoppers that they need to get six seeds to live. Give each thrush a brown sash and a large paper bag to collect the grasshopper bags. Tell them that they need to get four grasshoppers to live. Give hawks red sashes, and tell them that they must capture the large bags of two thrushes to live.

Note: These numbers have been arbitrarily chosen to accommodate an average class size. The more accurate estimate is 5 000 000 grass plants to support 500 000 grasshoppers to support 1000 thrushes to support one hawk.

Outline a game area. At one end of the play area, designate a safety zone and at the other end of the play area, a dead zone. Sprinkle sunflower seeds on the floor of the play area. Send the grasshoppers into the play area. Allow them thirty seconds to get their food. At the end of thirty seconds, the grasshoppers that do not have six seeds in their bags must go to the dead zone. The rest remain in the play area.

Tell thrushes that they will now have thirty seconds to get their four grasshoppers. When they capture a grasshopper, they will take the grasshopper's bag. Send in the thrushes. At the end of thirty seconds, any thrushes that do not have four brown bags and all captured grasshoppers must go to the dead zone. Any grasshoppers that are still alive must go to the safety zone. Have the thrushes that remain in the play area keep their large bags containing the bags from the grasshoppers they captured.

If there are at least two thrushes left in the play area, continue the game. Tell hawks that they will have thirty seconds in which to capture two thrushes. Tell them to take the large bag of a captured thrush. At the end of thirty seconds, any hawks that have two large bags from the thrushes and any thrushes that still have their bags go to the safety zone. All others must go to the dead zone.

It is unlikely that sufficient thrushes will survive to allow hawks to be sent in. If there are not at least two thrushes left, point out to the class that there is not enough food left for even one hawk. Thus all the hawks are automatically dead and must go directly to the dead zone.

Why are all the hawks dead?

Because there were not enough thrushes for them to eat.

Why were there not enough thrushes for them to eat?

Too many thrushes died because there were not enough grasshoppers for them to eat.

Explain to the class that the phrase "balance of nature" is used to describe a food chain in which enough members of each group survive so that all the groups can get enough food and continue to live. Tell class that its food chain was not balanced.

How can you tell?

Because all the hawks died.

For the food chain to be balanced, how many hawks would have to live?

At least one.

How many thrushes have to survive so that one hawk can live?

At least two.

For the two thrushes to have survived, how many grasshoppers had to live?

At least eight.

How many sunflower seeds were needed so that eight grasshoppers could live?

At least forty-eight.

Game B Change the number of grasshoppers to twenty-one and have five thrushes and two hawks. This set of numbers is still grossly inaccurate but is moving closer toward the actual proportion. The object of the game is to simulate the principle of a balanced / unbalanced food chain. If you ensure that there are enough sunflower seeds for all the grasshoppers, the use of the above numbers should result in at least one grasshopper, one thrush, and two hawks living at the end of the game. Replay the game. At the end of the game, ask questions similar to the following: How many grasshoppers got a full stomach? How many thrushes? How many hawks?

How are all three animals connected?

Each group eats the next one for food. They depend on one another to live.

What is the food chain in this game?

Plants, grasshoppers, thrushes, and hawks.

What would happen if there were only half as many plants?

There would only be half as much food as the grasshoppers need.

What would happen to the grasshoppers?

Some would die and some might leave the area in search of more food.

If there were no thrushes, what would happen to the grasshoppers?

The grasshoppers would increase in number because there would be no thrushes to eat them.

What would happen to the plants?

The increased number of grasshoppers would eat more and more plants.

What would happen to the hawks?

Without thrushes to eat, they would die.

If there were no hawks, what would happen to the thrushes and the grasshoppers?

The number of thrushes would increase because there would be no hawks to kill them and the increased number of thrushes would eat more and more grasshoppers. Soon there would be no more grasshoppers and some thrushes would die of starvation while others would leave the area to search for more grasshoppers.

How can a balance exist in a food chain?

If the correct number of animals exists at each level of the food chain, there will be enough food for all the animals and it will be balanced.

If you wish, at the conclusion of this activity you can have children draw a pyramid in their notebooks to represent the balanced food chain studied: 1 hawk, 2 thrushes, 8 grasshoppers, 48 seeds.

EXTENSION

Ratio and Proportion Have children go to the library and research the population and land area required of three or four cities and adjacent rural areas. They can then compare the land area allowed each person for the city dweller as well as the rural dweller. This study can include a comparison of over-populated countries with under-populated countries as well.

ENRICHMENT

How Much for How Many Have children compare a small bakery's loaf output with a large bakery's output and see how many people are fed by each bakery. Likewise, a large family's groceries can be compared with a small family's groceries, and so on.

Activity 8
What Comes In and What Goes Out

OBJECTIVES

22. **Identify major by-products of the fossil fuel-to-electricity energy conversion process.**
23. **Identify the effects of these by-products on the environment.**

Preparation Time
Core: 30 min

Instruction Time
Core: 60 min and four 10-min periods

Oral Vocabulary
scrubbers

Reading Vocabulary
by-product, carbon dioxide, carbon monoxide, environment, fly ash, nitrogen oxides, sulfur dioxide

Materials
Each child will need:
- Student Book
- Activity Sheet 4
- notebook / pencil

You will need:
- 2 small potted plants
- 2 large jars
- 2 lids
- 5 sticks of incense
- 5 matches

TEACHER BACKGROUND

Coal, cold water, and air are the raw materials for the production of electricity. The coal is burned in air to produce steam. The steam turns the turbine that spins the generator to produce electricity. Cold water is used to condense the steam. For every kilogram of coal, water, or air that enters a power plant, a kilogram of material leaves the plant. However, not all the material that leaves the plant does so in the form of electricity.

When any substance is burned, there are certain products of that burning. When coal is burned it produces water vapor, carbon dioxide, nitrogen oxides, sulfur dioxide, fly ash, and carbon monoxide. Water vapor and carbon dioxide are normal components of the atmosphere. The amounts given off are considered to be harmless to the environment although the long-term effect of increasingly large amounts of carbon dioxide of combustion are harmful to the environment. Nitrogen oxides and sulfur dioxide, when combined with water vapor, produce acids over a period of time. These acids fall with the rain, creating "acid rain." This acid rain has effectively killed all life in some lakes in Northern Europe, the Adirondacks, and Northern Ontario. It can also interfere with the growth of crops and trees as well as eat away buildings and monuments. Some companies have built taller smokestacks to minimize the damage to the land around power stations. This only distributes the pollutants over a greater area. A more efficient way to reduce the amount of these poisonous emissions is by "scrubbing" them out of the smoke. This process is expensive and adds to the cost of generating electricity but is being used by more and more companies.

Fly ash is made up of the tiny noncombustible particles found in coal. If it is released into the atmosphere, it creates a fine haze that eventually settles as dust. This dust is a prime component of smog and was one of the main causes of the "killer fogs" of London, England. Fortunately, the amount of fly ash coming out of a smokestack can be reduced by electrostatic precipitators that trap the particles as they come out of the stack. The collected fly ash can be dumped as fill or used in brick making and ceramics.

The carbon monoxide portion of the exhaust gas will eventually combine with the oxygen in the air and form carbon dioxide. As carbon monoxide however, it is extremely poisonous to warm-blooded creatures as it prevents the absorption of oxygen by the blood. This results in suffocation. The carbon monoxide content can be reduced by mixing more air with the coal during combustion.

With the exception of fly ash, the emissions just described are also produced when oil and natural gas are used to fire thermal generators.

Another pollution problem common to all thermal generating plants is waste heat. The steam

that drives the turbines must be cooled and condensed before it can be reused. This requires large amounts of cooling water. After the steam has passed through the condenser unit, the cooling water is often warmer than the water in the river or lake it came from. When the cooling water is piped back into the river or lake, it can change the temperature. This thermal pollution changes the environment around the river or lake by encouraging the growth of different kinds of plant and animal life. This waste heat could be used to heat greenhouses or nearby buildings.

CORE ACTIVITY

Write the word *environment* on the chalkboard. Have children speculate about its meaning. If no one knows, explain that environment is another word for "surroundings"; that all things around us make up our environment. Remind children of Activity 5 and how we can use fossil fuels, such as oil, gas, and coal to generate electricity. Have children speculate about whether generating electricity by burning fossil fuels can harm our environment. If they do not come up with the idea that smoke from power stations does affect the environment, tell them it does.

Tell class that it will do a simple five-day experiment to show how smoke will affect living things. Have children turn to page 15 in their Student Books. You should do the experiment, but have children take turns reading out the steps. Put the observation chart on the chalkboard. Hand out Activity Sheet 4 and have children copy the chart in their notebooks or on the back of the Activity Sheet and record changes for five days.

Tell children to turn to the diagram of the inputs and outputs from a coal-fired generating plant on page 14 of their Student Books. Go over the labels, making sure that children understand each one. Explain that nitrogen oxides, sulfur dioxide, carbon monoxide, and carbon dioxide are gases and that fly ash is a type of ash that is very fine. Explain that these things are by-products of burning coal to produce electricity. Write the word *by-products* on the chalkboard. Tell children that we burn coal to produce heat but that when we burn coal other things are also produced. These things, which are not the main product, are called by-products.

Tell children to look at the outputs. Explain that both water vapor and carbon dioxide are part of our air. Water vapor is not harmful to the environment. Carbon dioxide is not harmful; plants use it to make food. But, we don't know what effect large amounts of carbon dioxide have on us. Tell children that coal ash can be harmful if dumped in water sources. On land, it must be carefully dumped too. Large amounts could ruin good land.

It is unlikely that children will know about nitrogen oxides, sulfur dioxide, carbon monoxide, or fly ash. Tell them that nitrogen oxides and sulfur dioxide are very harmful to the environment. When they are released, they combine with water vapor to form an acid. This acid falls with the rain. It has effects that we are just beginning to understand, such as killing fish in lakes, interfering with the growth of trees and crops, and even causing buildings and statues to crumble. Tell children to look at the pictures on page 15 of their Student Books. Have one child read the captions. Stress that it takes a long time before we notice the effects of the acid in rain on our environment.

Have children speculate about fly ash and carbon monoxide being harmful and what effect they have. Carbon monoxide keeps oxygen from being absorbed in the body's blood and this can result in death. Fly ash can cause smog, which affects the lungs. Have children speculate about whether the hot water produced in the cooling process can harm the environment and what effect it has. The hot water can change the temperature of the air, the river, or the lake.

Have children fill in Activity Sheet 4 to show which products are harmful and which ones are not. Review the answers: **electricity**- P/N; **hot water**- BP/H/ changes temperature of air, water; **coal ash**- BP/H/ruin good land or water; **fly ash**- BP/H/causes smog; **water vapor**- BP/N; **nitrogen oxides**-BP/H/can cause acid in rain; **sulfur dioxide**- BP/H/acid in rain; **carbon dioxide**- BP/N; **carbon monoxide**- BP/H/affects lungs, cannot breathe. Have children put their completed Activity Sheets in their energy folders.

Tell children that these by-products are produced when other fossil fuels are burned to generate electricity. Fly ash is produced only when coal is burned, but the other by-products are produced when oil or natural gas is burned. Tell class that there are ways that these poisonous by-products can be controlled and many companies are using them. For example, scrubbers in smokestacks will take out most of the nitrogen oxides and sulfur dioxide. Another kind of machine attached to the smokestacks will take fly ash out. This fly ash can be used for brickmaking. The heat from the water used to cool the steam can be used to heat buildings or greenhouses close to the generating station.

	First Day	Second Day	Third Day	Fourth Day	Fifth Day
Plant 1 No smoke	green, healthy				
Plant 2 Smoke	green, healthy				

Activity 9
How We Use Electricity at Home

OBJECTIVES

24. **Recognize electrical appliances as consumers of energy.**
25. **Identify the major consumers of electricity in the home.**
26. **Calculate the energy used by these consumers in kilowatt hours.**

Preparation Time
Core: 20 min
Extension: 10 min

Instruction Time
Core: 30 min
Extension: 30 min

Oral Vocabulary
ampere(age)

Reading Vocabulary
appliance, kilowatt hour (kW·h)

Materials
Each child will need:
- Student Book
- Activity Sheet 5
- pencil

TEACHER BACKGROUND

In order for children to learn that they must use all of our energy sources wisely, they must appreciate how much we use and depend on them. This activity is designed to show children how much electricity is consumed by ordinary household appliances and which ones consume the most.

The watt is a measure of power; the kilowatt hour is a measure of energy. The rate at which an electrical appliance consumes energy is measured in watts or thousands of watts (kilowatts). For most household appliances, the number of watts is indicated on an attached sticker or plate. This power may be as little as one or two watts for an electric clock, or up to twelve thousand watts (or twelve kilowatts) for an electric stove in full use.

To measure the amount of energy consumed by an appliance we must take into account not only the number of watts but also the length of time that the appliance was used. The most common measure of electrical energy consumption is the kilowatt hour. A kilowatt hour represents the electrical energy of one kilowatt consumed in one hour. In more practical terms, a kilowatt hour is the amount of electricity consumed by ten 100-W lightbulbs over an hour, or it could be thought of as the amount of electricity consumed by one 100-W bulb over ten hours. To calculate the number of kilowatt hours used by the appliance, simply multiply the number of watts by the number of hours it is used and divide by 1000. For example, a 6000-W clothes dryer used for 1.5 h consumes

$$\frac{6000 \times 1.5}{1000} = 9 \text{ kW·h of electricity.}$$

If you are interested in computing the cost of operating the dryer for that time, you will have to know your local cost of a kilowatt hour of electricity. If the cost were 8¢ per kilowatt hour, the cost of operating the dryer in the example above would be $9 \times 8¢ = 72¢$.

Children may find that the number of watts consumed by some appliances varies widely. For example, a radio can consume anywhere from 1 W to 100 W. The reason for this wide variation is our advance in technology. Transistor radios use very little electricity whereas old tube-type radios consume a lot of electricity, most of which is wasted as heat.

Sometimes the electric current or number of amperes (A or amps) is indicated on an appliance rather than the number of watts (W). If the appliance operates on a normal 120-V household current, you can compute the number of watts by multiplying the number of amperes by the number of volts. Thus a fan using 2.3 A would use

$$2.3 \times 120 = 276 \text{ W.}$$

CORE ACTIVITY

Remind children of Activity 5 "From Coal to Kilowatts" and that much of our electricity is generated by nonrenewable sources of energy. Electrical appliances are one more step in the conversion chain. They turn electricity into heat and/or light, and motion.

Have children turn to page 16 in their Student Books. Tell them that this is a cut-away cross-sectional view of an ordinary house. Ask children to point out the various electrical energy users shown in the picture. Put the items on the chalkboard as children tell you about them. Tell children that these electrical energy users are called *appliances.* Write the word on the chalkboard and ensure that all children can read and pronounce it.

Pass out Activity Sheet 5, "How We Use Electricity at Home." Go over the list of appliances on it to ensure that children can read, pronounce, and understand each one. Have children check off the appliances that they use at home. Tell children that the numbers on the right side of each column represent the amount of electrical energy that the appliances need to operate. They can find out how much electrical energy each appliance uses by multiplying the number of watts by the number of hours the appliance is used and dividing by 1000.

Pick one of the appliances and demonstrate the procedure to the class.

Tell children that the final number arrived at represents *kilowatt hours.* Write the word on the chalkboard. Explain that a kilowatt hour is a unit that measures the amount of electrical energy that an appliance has used. Write *kW·h* on the chalkboard and explain that this is the symbol for kilowatt hour.

On the back of their Activity Sheets, have children calculate the number of kilowatt hours used for each appliance they have checked off. Help them to estimate the number of hours each appliance is used. Tell children that the power company charges by the kilowatt hour. If you wish, have the children calculate the cost of running some appliances for an average day. Have them put their Activity Sheets in their energy folders.

EXTENSION

The Light in Our Life In many places, both at home and in school, a 60-W lightbulb can be used in place of a 100-W bulb. Have children count the number of 100-W lightbulbs in their homes (or classroom) and calculate how much energy would be saved by using 60-W bulbs instead.

Average life of a bulb = 1000 h
60-W bulb uses 60 kW·h
100-W bulb uses 100 kW·h
Saving = 40 kW·h × number of bulbs

Since 500 g of coal produce 1.5 kW·h of electricity, have children calculate how much coal would be saved.

Activity 11
From the Well to the Car

OBJECTIVES

28. Examine the steps required to produce gasoline from petroleum.

29. List the main products of petroleum refining.

Preparation Time
Core: 15 min
Extensions: 10 min

Instruction Time
Core: 60 min
Extensions: varies

Oral Vocabulary
atom, petroleum

Reading Vocabulary
asphalt, crude oil, diesel oil, gasoline, kerosene, molecule(s), product(s), refine(ed), refinery(ies), substance(s)

Materials
Each child will need:
- Student Book
- Activity Sheet 7
- notebook / pencil

TEACHER BACKGROUND

Crude oil is a complex mixture of many compounds, which have two things in common: they can all be burned, and they are mainly molecules composed of hydrogen and carbon atoms called hydrocarbons. Crude oil from the well often contains water and natural gas. The water and gas are removed from the oil, which is then stored in tanks ready for shipment to the refinery. Once the oil is delivered to the refinery by ship, rail, or pipeline, it is again stored in tanks until it is refined.

At the refinery, crude oil is transformed into many different products. Gasoline constitutes about 40% of the production material. Other fuels and products include kerosene and stove oil; domestic heating oil; bunker fuels for ships, power-generating stations, and large industrial plants; aviation fuels; gas fuels; lubricating oils; greases, waxes, and asphalts; and petrochemical feedstocks for plastics manufacturing.

The first step in the refining process is the separation of crude oil into its various fractions, or parts, by distillation. The crude oil is heated inside a furnace to about 345°C. At this temperature, about 65% of the crude oil changes to vapors, which pass to a distillation tower. As the vapors rise inside the tower, they are cooled by heat exchangers. Water plays an important role as a cooling agent near the top of the tower in the condenser unit. This water is returned to the environment. As the vapors cool, they condense at different temperatures and levels in the tower. For example, furnace fuel, a heavier fraction, starts to condense at around 370°C and is totally liquid at about 22°C. It is collected about halfway up the tower. Gasoline, a light fraction, starts to condense at 200°C and is totally liquid at about 32°C. It is drawn off near the top of the tower.

The second step in the refining process is to change some of the fractions into other, more useful compounds by changing their chemical structure. This process is called conversion. There are a variety of ways of converting oil. For example, the gasoline obtained from the first distillation goes to a reforming unit where the form, or shape, of the gasoline molecules is changed. This process produces gasoline powerful enough for modern cars, which require higher octanes. More gasoline can also be produced from heavier fractions like gas oil. The gas oil is heated under pressure in the presence of a catalyst and breaks down to form gasoline and lighter fuel oils. These components are separated in another distillation tower.

Nearly all the products that come from distillation and other major conversion processes contain small amounts of impurities, such as sulfur, wax, and sludge. Some of these give the product a bad odor, and others may cause rust or unnecessary wear. Treating removes these impurities. Some treating methods are complicated. Others are simple, such as passing the product through a solution of lye and water. Water is also used to remove such unwanted materials as hydrogen sulfide — a poisonous gas.

Finally, gasoline must be carefully blended to obtain a product with all the qualities needed to do the job properly. Various substances are added to improve performance. A special oil is sometimes added to help protect the engine from wear. Butane can be added for quick starts in the winter. Other compounds are added to keep the engine clean and prevent the formation of deposits. And, substances may be added so that the gasoline will keep well in storage.

CORE ACTIVITY

Because the conceptual level of the material in this activity tends to be difficult, you will need to work through it carefully with the children. Most of the difficult terms relating to the processing of petroleum have been omitted from the student material. These terms have been included in the teacher background for your convenience.

Have children speculate on where gasoline comes from. They might suggest an answer such as "the gas pump." Tell children that gasoline is one of the products that comes from crude oil. Tell children that petroleum is another word for crude oil. Write *gasoline*, *product*, and *crude oil* on the chalkboard. Ask children for the names of other products that can come from petroleum. List headings such as *home*, *transportation* (the family car), and *workshop* on the chalkboard to help children think of the names of petroleum products with which they are familiar.

Write the words *refine*, *refinery*, *substance*, *molecules*, *kerosene*, *diesel oil*, and *asphalt* on the chalkboard. Speculate with children on their meaning. Tell children that *refine* means "to make something more pure" and that a *refinery* is "a place where something is made purer." Explain that things can be called substances. A substance can be a solid, a liquid, or a gas, and all subtances are made up of tiny invisible units called atoms. Several atoms can join together to form bigger invisible units called molecules. Point out that kerosene, diesel oil, and asphalt are other products that can be made from crude oil. Ensure that children can read and pronounce each word.

Have children turn to pages 18 and 19 of their Student Books. Follow the reading with children and stress the following points as you come to them.

Tell children that in step 3, each different substance that makes up crude oil boils at a different temperature. Gasoline boils at 32°C while the fuel oil used in home furnaces boils at 200°C. Crude oil is heated to a high temperature (345°C) so that most of the liquid substances in it will boil and form vapors.

In step 4, steam, made by heating water, is mixed with the gases entering the tower near the bottom. This makes the process more efficient. Water is also used near the top of the tower to absorb heat and cool the rising vapors. This warmed water is returned to the environment.

In step 6, water and other substances are used to treat and remove unwanted things like sulfur. Other things that can make a product less pure are waxes and sludge.

Have children answer the questions that follow the reading in their notebooks or on the back of Activity Sheet 7. These are possible answers: **1.** It is a fossil fuel that formed from the bodies of plants and tiny animals that died millions of years ago. **2.** Many different substances: some are liquids, others are solids and gases. **3.** Most of the things in crude oil can be burned. **4.** Natural gas and water are separated from it. Then it is stored in tanks. **5.** Its many different parts boil and turn to vapors. **6.** They rise, are cooled, and become liquid at different levels. **7.** The bottom is hottest. The top is the coolest part. **8.** Near the top. **9.** To clean it of substances that would hurt the engines in cars.

10. To make the different types of gasoline needed for tractors, trucks, and cars, and for different weather conditions.

Have children turn to page 20 of their Student Books. Examine with them the illustration of some of the products that can be made from crude oil. State that gasoline, kerosene, and jet fuel are made from the lighter parts that come out near the top of the tower. The heavier parts that come out near the bottom of the tower are used to make fuel oil for ships and asphalt for roads. Elicit other products shown in the illustration and the ways they are used. Have children copy the names of five products into their notebooks.

To conclude this activity, have children complete sequencing the phrases and words for the diagram on Activity Sheet 7. These are possible answers: **1.** sun shone, plants and tiny animals lived **2.** plants and tiny animals die, eventually form fossil fuel **3.** crude oil from well **4.** water and natural gas **5.** tank **6.** railway, pipeline, or tanker **7.** furnace **8.** tower **9.** raw gasoline **10.** treated and blended **11.** pump.

EXTENSIONS

Petroleum Products Tell children to make a list in their notebooks of as many petroleum products as they can find in their homes. Have them also indicate the use of each product.

At the Gas Station Have children find out how many different blends of gasoline are available at their local service station (regular, premium, unleaded regular, unleaded premium, diesel fuel). If their family owns a car, ask them to find out which blend of gasoline it uses.

Activity 12
Oil Refining and Our Environment

OBJECTIVES

30. **Identify the environmentally harmful by-products of petroleum refining.**
31. **Describe how this pollution can be prevented.**
32. **Recognize that the burning of oil products is a major cause of pollution.**

Preparation Time
Core: 25 min

Instruction Time
Core: 45 min

Oral Vocabulary
transported

Reading Vocabulary
evaporate(ing), floating roof, landfill area, pollution, settling pond

Materials
Each child will need:
- Student Book
- Activity Sheet 8
- notebook / pencil

You will need:
- Filmstrip and cassette, *Energy: How We Change It* (optional)
- projector / screen

TEACHER BACKGROUND

Although oil and gas are confined inside pipes and towers during processing, some environmental harm can still be caused by wastes and the by-products of refining. Large amounts of water are used in oil refining, but these amounts are being reduced. Methods of treating the water vary. Oil and solids from refineries can be removed in settling basins where the solids sink to the bottom and oil is skimmed from the top for return to the refinery. Other waste waters containing phenols, sulfides, and ammonia must be specially treated.

Sulfur compounds in gas and oil products can be a threat to the environment, contributing to acid rain and other problems. They can be converted into saleable sulfur, burned as fuel, or vented if the amounts are small and the plant is in a remote location. Special collectors can be used to catch the catalyst dust given off from the fluid catalytic crackers in refineries. Carbon monoxide from the same units can be burned to generate steam.

Many refinery products evaporate easily, creating the possibility of expensive losses and pollution of the atmosphere. Floating roofs sealed with inflatable gaskets on large storage tanks holding volatile products help reduce evaporation, cut losses, and lessen pollution.

Waste gases can be mixed with steam to burn them completely. But because refineries use large quantities of water, clouds of steam and water vapor are common, particularly in cold weather. These do not affect the environment unless they contain harmful air contaminants.

Refineries are also noisy. Although most refineries were built in relatively unpopulated areas many years ago, population has closed in around them, so it is important that noise be kept to a minimum. This can be done by putting mufflers on exhaust stacks and vents; installing noise shields on pumps, motors, and burners; and building sound-deadening walls around noisy areas. Sometimes one kind of pollution control can lead to another kind of pollution. For instance, refinery waste gases are burned safely and with little pollution in flare stacks that have steam injected into them. The steam causes the gases to burn without smoke. However, too much steam in a stack makes extra noise, so the stacks have to be carefully monitored, often by closed circuit television.

Many refineries have done much to reduce their various sources of pollution. Oil and gas refining is relatively non-polluting, particularly when compared to the thermal generation of electricity. In fact, emission statistics for an area with many oil refineries and many fossil fuel generating plants showed these percentages.

	Percent of Total Emissions				
	Particulate matter	Sulfur dioxide	Nitrogen dioxide	Hydrocarbons	Carbon monoxide
Refineries	0.1	0.6	0.4	0.5	0.1
Power Generating Plants (fossil fuels)	48	14	26	0.6	0.5

The refining process is quite efficient. Typically, for every one hundred barrels of crude oil, ninety-four barrels of saleable material can be recovered.

Most petroleum pollution comes from the end use of the refined product.

CORE ACTIVITY

Filmstrip Energy: How We Change It, *frames 22 to 31, may be used to* introduce *this activity.*

Remind children of Activity 8, and how the emissions and by-products from coal-fired generating stations can be harmful to the environment. Tell them that we are now going to study how the by-products and wastes from the refining of crude oil can affect our environment, and what refineries can do to make dangerous substances less harmful.

Tell children to turn to pages 18 and 19 and reexamine the "From the Well to the Car" picture. Have the class speculate on which of the steps in the crude oil conversion process could be harmful to the environment. Tell children that accidents can happen while oil or other refinery materials are being transported or moved from one place to another. Pipelines can break and leak oil; oil tankers can run aground or be damaged during sea storms and spill oil; tanker trucks or trains that carry oil and other refined materials can have accidents; and sometimes explosions and fires occur at refineries. Elicit that oil or other refinery materials released by these types of accidents can harm our environment. Stress that even though these accidents do happen, they are not a main cause of pollution, or the dirtying of the environment by harmful substances. For example, only 5% of the oil spills at sea result from accidents.

Write these vocabulary words on the chalkboard: *pollution, evaporate, settling pond, floating roof, landfill area.* Tell children that *evaporate* means "to turn into vapor" and that *landfill areas* are places where solid wastes are carefully buried. Settling ponds and floating roofs are two things used to control possible sources of pollution at refineries. Ensure that children can read, understand, and pronounce each word.

Have children turn to page 21 in their Student Books. As you follow the pictures / photographs and captions with them, discuss the following points listing them on the chalkboard.

For the photograph of the refinery, elicit from children how water is used in refineries: to cool vapors near the top of the refinery tower; to make steam that is mixed with crude oil vapors near the bottom of the tower. Tell children that the heat that water picks up is usually not used. This warm water can change the environment if returned to its original source. Elicit that steam and water vapor are not harmful.

Tell children that carbon monoxide, a harmful conversion by-product, can be burned to make steam to help run the refinery. Other waste gases can be mixed with steam and burned completely in flare stacks so that no smoke is given off. Sometimes refineries do release small amounts of waste gases into the air, or larger amounts if the refinery is in an isolated area.

Have children speculate on whether or not noise is harmful. Tell class that noise made by machines used in refineries is also a type of pollution. This noise pollution can be lessened by building refineries far away from areas where there are lots of people. For refineries near cities or towns, special equipment and shields can be put on stacks, pumps, motors, burners, and other machines, and walls can be built around particularly noisy parts of the refinery.

For the picture of the settling pond, elicit from class that sulfur and solid wastes like sludge are removed from materials during treating. Tell children that, if sludge is not handled carefully, rainwater can wash harmful substances from it into the soil or nearby water sources. Water used for treating, if returned to its source, will have the same effect. Tell children that when some materials with sulfur in them are burned, they give off bad odors that aren't harmful. Elicit that other materials with sulfur in them can form sulfur dioxide, a harmful gas, when burned. These materials are burned in chimneys with special collectors that trap the sulfur. Stress that floating roofs help prevent air pollution as well as loss of precious refinery materials.

For the photographs at the bottom of the page, tell children that refineries take many steps to prevent pollution, partly to protect the environment and partly to save money. From every 100 barrels of crude oil brought into a refinery, 94 barrels of usable material is made. Stress that much pollution comes from the burning of fossil fuels to produce heat. The conversion of coal to electricity is a dirty process, but electricity is clean to use.

Hand out Activity Sheet 8. When children have filled out the chart, have them copy the chalkboard notes onto the back of their Activity Sheets or in their notebooks. Then correct their answers. **1. warm water** — yes / returned to source; **waste gases** — yes / mixed with steam, burned, or small amounts released; **steam, water vapor** — no; **sulfur** — yes / removed by special collectors in chimneys; **water for treating** — yes / treated in settling pond; **substances that evaporate** — yes / stored in tanks with floating roofs; **carbon monoxide** — yes / mixed with steam, burned safely; **sludge** — yes / removed and sent to landfill area; **oil** — yes / reused. **2.** Electricity produced by burning coal. **3.** Using oil.

For the next class, you will need to bring the following items or pictures of them: foam cup, plastic bag (containers); foam cushion, plastic castor (furniture); polyester socks, sweater (clothing); bicycle tire, automobile tail-light cover (transportation); plastic toy, record, game with plastic pieces (leisure); and polypropylene rope, plastic clothespin (fasteners).

Activity 13
Our Plastic World

OBJECTIVES

33. Identify and classify petroleum-based products.

34. Assess our dependence on fossil fuels to maintain our lifestyle.

Preparation Time
Core: 20 min
Extension: 10 min
Enrichment: 10 min

Instruction Time
Core: 60 min
Extension: 30 min
Enrichment: 30 min

Oral Vocabulary
none

Reading Vocabulary
acrylic, foam, Fortrel, jogging, nylon, plastic, polyester, pyjamas, Teflon, vinyl

Materials
Each child will need:
- Student Book
- Activity Sheet 9
- notebook / pencil

You will need:
- foam cup, plastic bag (containers); foam cushion, plastic castor (furniture); polyester socks, sweater (clothing); bicycle tire, automobile taillight cover (transportation); plastic toy, record, game with plastic pieces (leisure); and, polypropylene rope, plastic clothespin (fasteners); or pictures of these objects

TEACHER BACKGROUND

Today, we are highly dependent on petrochemicals. Indeed, whatever we do and wherever we live it is almost impossible to avoid using products made wholly or partly from them. Much of our clothing is now made from such synthetic fibers as rayon, nylon, and polyester instead of wool or cotton. Carpeting, drapes, electrical plugs, cushions, chairs, flooring, and many other home furnishings are made of petrochemical products. Our food is packaged in plastic containers and plastic wrap. We drive in automobiles, airplanes, and boats made largely of plastic, and we use plastic toys, models, and games in our leisure time. Our dependence on petrochemicals increases with every day.

The main ingredient in petrochemicals is carbon, which is derived from such natural sources as oil or natural gas. Coal and wood can also be used to produce petrochemicals. However, our main source today is petroleum, because it is the cheapest and most easily used. In the refining process certain crude oil fractions or natural gas components are changed to products that can be used to form petrochemicals. Petroleum feedstocks may be supplied to the chemical industry by the oil companies. Alternatively, oil companies may manufacture the chemicals themselves or enter into joint operations with chemical companies.

Petrochemicals are distributed to various different industries that turn them into inks, synthetic lubricating oils, detergents, and such rubber products as shock absorbers and safety bumpers for cars. Nylon is sent to mills where it is made into cloth. Synthetic rubber is shipped in bales to tire and rubber companies where it is made into tires, tubes, and other rubber products. Polyethylene pellets are molded by plastic processors into film or sheets for use in such products as plastic bags and garden hose. While petrochemicals are possibly most used in the plastics processing industry, they are used widely in forestry, mining, textile manufacturing, construction, and agriculture as well.

In the future, petrochemicals will play a large role in helping us realize a conserver society in which materials are constantly recycled and products refuse to wear out. Such products may include unbreakable dishes, indestructible clothing, cars, boats, and airplanes made entirely of plastic, buildings made of parts that snap together, and bubble tops for entire cities made of indestructible, clear film. Petrochemicals have the potential to make all of this possible.

CORE ACTIVITY

Set up your samples or pictures of items made from plastic so that all children can see them easily. Put these headings on the chalkboard: *Containers, Furniture, Clothing, Transportation, Pleasure, Fasteners.* Now have children classify the objects according to their use and record their answers.

Speculate with children on what these products have in common. To aid the speculation, ask children to turn to page 20 in their Student Books and reexamine the crude-oil-products illustration. Children should be able to tell you that all the products are made from petroleum. Point out the various products that aren't fuels – creams, weed killer sprays, rubber tires, wax paper. Make sure that children realize what a wide variety of products is derived from petroleum.

Put these vocabulary words on the chalkboard: *acrylic, foam, Fortrel, jogging, nylon, plastic, polyester, pyjamas, Teflon, vinyl.* Make sure children can read, pronounce, and understand the words. You could use the samples you brought in to demonstrate what some of the vocabulary words mean.

Have children turn to page 22 in their books and read "My Plastic Morning." Ask them to list in their notebooks or on the backs of Activity Sheet 8 the products mentioned that are made from petroleum. When they have finished, have individual children suggest specific products and list them on the chalkboard.

Have children look at the illustration on page 23 of their Student Books. Point out that the oil from which these products are derived is nonrenewable. Once it is used, it cannot be replaced. Elicit from children that we must not waste oil because it cannot be replaced. Have children speculate on different ways to avoid wasting oil. Direct the responses toward those ways that require a personal effort such as buying fewer things, taking better care of the things we have, reusing things instead of buying new ones, driving less, and walking more. Elicit from children that it will become more necessary to conserve oil in the future as oil supplies dwindle.

Hand out Activity Sheet 9. Tell children to color in as many petroleum-based products as they can find. When they have finished, list these products on the chalkboard so that children can check their work. Then have children file their completed Activity Sheets in their energy folders. The answers are: venetian blind, bathrobe, plastic hair brush, records, lamp shade, stuffed toy, television cabinet, countertop, shower curtain, hair dryer, shampoo and bottle, plastic flower pot, shopping bag, chair, telephone.

Speculate with children on what our world would be like without petroleum. Remind children of how much petroleum is wasted and that such waste will not be possible in the future. To end on a positive note, tell children that plastics and other similar materials may one day help us to reduce our waste of petroleum. Someday these materials will be used to make products that never wear out.

EXTENSION

Use of Petroleum in School Ask children to determine which products in the classroom are derived from petroleum. Have them list these products in their notebooks and decide which they consider essential and which they feel they can do without.

ENRICHMENT

Language Arts Before Plastics Existed Ask children to write a paragraph describing the world of one hundred years ago when petrochemical products did not exist.

Activity 14
Oil: The Amount We Use

OBJECTIVES

35. **Recognize our current rate of petroleum consumption.**
36. **Suggest ways of using energy derived from oil and other fossil fuels more wisely.**

Preparation Time
Core: 20 min
Enrichments: 10 min

Instruction Time
Core: 60 min
Enrichments: 30 min

Oral Vocabulary
none

Reading Vocabulary
nuclear energy

Materials
Each child will need:
- Student Book
- notebook / pencil

You will need:
- 1 L of motor oil
- 1 1.5-L pan
- metric measuring cup and spoons
- Filmstrip and cassette,
  Energy: How We Change It (optional)
- projector / screen

TEACHER BACKGROUND

Every year we use more and more of our nonrenewable energy supplies. Today everyone is worried that these supplies will soon run out. Not very long ago this was not a major concern. Until the middle of the nineteenth century, animals were the main source of energy available to do work. Since they were a renewable source of energy, there was no need to worry about using up the energy available. Once new technology enabled us to utilize the cheaper and more efficient energy supplied by fossil fuels, however, the energy drain began.

Our technology naturally shifts to the energy source that is most easily available and most economical. In the past, this has meant a movement from animal energy to wood, to coal, and most recently to oil and natural gas. In North America, oil supplies almost half of our total energy needs, as the following estimates indicate: petroleum supplies 45%; natural gas supplies 22%; coal supplies 14%; hydroelectric power supplies 15%; nuclear energy supplies 4%.

Because of advances in technology and an abundance of cheap fuel, our consumption of oil has multiplied rapidly. Recent surveys indicate that our use of oil is doubling every ten years. For example, in 1965, each automobile contained about 75 kg of plastic parts; in 1979, this had increased to 440 kg. In 1968, about 103 kg of plastic was used by each North American; ten years later this use had increased to 224 kg.

Although no one is certain how much oil remains to be extracted, most experts agree that our supplies will eventually be exhausted. If we continue doubling our consumption every ten years, we may not have adequate time to develop other energy sources to replace oil.

Exploration for new oil deposits is becoming increasingly expensive as well. As long as there are abundant sources, the return on the money invested in exploration for new oil deposits is high. As supplies are exhausted, however, more money must be spent to discover whatever is left. The most accessible deposits of oil in North America have already been developed, and we are now forced to develop new, expensive technology to recover oil from such sources as the oil sands in Alberta.

It is becoming more and more apparent that we need to eliminate our waste of oil-based products and get more from each unit of oil used. We can use our dwindling supplies of energy wisely by concentrating on three means of conservation. We can improve the energy efficiency of our buildings, vehicles, and industrial equipment. We can substitute energy-efficient goods and services for energy-intensive ones. And, we can curb the need for energy services. If we fail to use our energy wisely now, we risk facing a future in which there is insufficient energy to maintain the lifestyle we desire.

CORE ACTIVITY

Filmstrip Energy: How We Change It, *frames 36 to 44, may be used at the end of this activity to* review *the concepts introduced.*

Write the word *nuclear energy* on the chalkboard. Explain to children that nuclear energy is another type of energy used to produce heat for generating electricity. Ensure that children can read and pronounce the word. Have children turn to pages 24 and 25 in their Student Books, read the text, and answer the questions that follow in their notebooks. Discuss answers with class. These are possible answers: **1.** There was a shift to oil because it was cheaper to use. Also, machines were made that could use this fuel. **2.** Oil. **3.** North Americans. **4.** We use oil in transportation, in our homes, schools, offices, and factories. **5.** It will run out unless we find a lot more or cut back on our use.

Explain to children that we may know of areas where there is a lot of oil, but it may be too expensive to get the oil from these places. Or, we may not know a good method for extracting this oil. In Alberta for example, there are areas of shale rock that contain a lot of oil. Much of this oil is now extracted by a complicated and expensive process. The rest is left because we don't know how to extract it yet.

Have children examine the illustration and read the caption on page 25 of their Student Books. Tell children that the amount of oil we have been using has been doubling every ten years. To indicate what this consumption rate means, take a 1-L container of motor oil and suggest that it represents the amount of oil remaining in the world. Remove the oil from the container starting with 1 mL and doubling the amount removed each time. Each amount removed represents the amount of oil used in ten years. Work with children to develop the following chart on the chalkboard. Elicit from class that we would run out of oil in about one hundred years.

	Amount Used	Amount Remaining
1st ten years	1 mL	999 mL
2nd ten years	2 mL	997 mL
3rd ten years	4 mL	993 mL
4th ten years	8 mL	985 mL
5th ten years	16 mL	969 mL
6th ten years	32 mL	937 mL
7th ten years	64 mL	873 mL
8th ten years	128 mL	745 mL
9th ten years	256 mL	489 mL
10th ten years	512 mL	will run out here

Have children speculate on how their futures would be affected if this experiment were to be true. Stress that as they got older, oil would become more scarce; there would be fewer oil-based products; and the little there would be left would be quite expensive. Elicit that we must find ways of using energy from oil and other fossil fuels more wisely, if we want to keep enjoying our way of life in the future.

Write the following headings on the chalkboard: *Home, School, Office.*

Transportation. Have children suggest ways of using energy more wisely and list these under the appropriate heading. Possible suggestions could include: turn lights, machines, radios, off when not in use; use car pools or public transportation; use the telephone or bicycles instead of cars; recycle plastic products to cut down on waste; use cars that don't waste gasoline. When you have completed the discussion, have children copy the list into their notebooks.

ENRICHMENTS

Language Arts **The Future Without Oil** Have children write a paragraph describing what life will be like when all the oil is used up.

Language Arts **How I Can Conserve Oil** Have children write a paragraph describing how they can change the way they live in small ways so that they use less oil and fewer oil-based products.

Activity 15
The Long and the Short of It

OBJECTIVES

37. **Identify long and short conversion chains.**
38. **Compare long and short conversion chains in terms of their energy use and effect on the environment.**
39. **Deduce that shorter chains use less energy and produce less waste than long chains.**

Preparation Time
Core: 20 min
Extension: varies

Instruction Time
Core: 45 min
Extension: varies

Oral Vocabulary
none

Reading Vocabulary
none

Materials
Each child will need:
- Student Book
- Activity Sheet 10
- notebook / pencil

CORE ACTIVITY

Remind children of Activity 6, "Energy Flow in Food Chains." Ask children to give an example of a food chain. Elicit from them that energy is lost as it moves from producer to consumer. Elicit that the same thing happens when we convert coal to electricity for lights and appliances or crude oil to gasoline to run cars.

Have children speculate about which energy conversion chain uses the most energy — walking to school, or having their parents drive them to school. Some children might say that walking uses more energy — thinking of their own personal energy. Ask the class to turn to pages 26 and 27 in their Student Books. Tell them that these illustrations are the two conversion chains they just discussed. Go through each chain, step by step, making sure that children understand each one. Stress that the chains we are tracing are for the energy sources used: food and gasoline.

Elicit from children how walking to school saves energy. If in your earlier discussion some children speculated that walking used more energy, they will be able to see why this is not so. Make sure that they understand that because there are fewer conversion steps, less energy is lost in total. State that we cannot recover any of the energy lost in either conversion chain; so the only way we can save energy is to use it wisely, that is, to choose shorter chains.

Elicit from children the conversion chains for reading in sunlight and for reading with an electric light. As children describe the chains, put them on the chalkboard.

sun shines → child reads

sun shines → plants grow → plants die → coal formed → coal extracted → coal burned to generate electricity → electricity sent to home → child turns light on → child reads

Ask children if they know of other short and long chains, such as, cutting lawns with a hand mower instead of a power lawnmower, using a towel to dry hair instead of a hair dryer, growing vegetables instead of buying them.

Hand out Activity Sheet 10. Ask children to fill in the conversion steps in the short chains and the long chains. When they have finished, check their work and have them put the sheets in their energy folders. The answers for Activity Sheet 10 are: **Short Chain** — sun shines → trees grow → trees chopped down and cut into logs → logs set on fire → food cooked over fire. **Long Chain** — sun shines → plants grow and die → coal formed → coal extracted → coal burned to generate electricity → electricity sent to home → stove turned on → food cooked.

Tell children that it is not always possible to use a shorter conversion chain. We cannot read in the sunlight when it's raining or dark; we cannot visit relatives who live 50 km away on foot; it's not practical to harvest 100 ha of wheat without a combine. However, when there is a choice, choosing the shorter chain is a way of using energy wisely, because shorter chains use less energy and do less harm to our environment.

EXTENSION

Make a Solar Hot Dog Cooker To demonstrate how we can use short conversion chains, have children make a simple solar hot dog cooker. Many plans for making cookers are available, but one of the best is described in *Energy Conservation Experiments You Can Do . . . from Edison* available from the Thomas Alva Edison Foundation, 143 Cambridge Office Plaza, 18280 West Ten Mile Road, Southfield, Michigan 48075.

Activity 16
Use It If You Can

OBJECTIVES

40. Identify by-products from energy conversion processes.

41. Identify uses for these by-products.

42. Determine uses for other by-products.

Preparation Time
Core: 20 min

Instruction Time
Core: 60 min

Oral Vocabulary
none

Reading Vocabulary
butane, ethane, fertilizer(s), methane

Materials
Each child will need:
- Student Book
- Activity Sheet 11
- notebook / pencil

TEACHER BACKGROUND

The natural gas used in homes and industry is almost pure methane. The gas that comes out of the ground contains many other substances. These include water, hydrogen sulfide (both poisonous and corrosive), carbon dioxide, gases in liquid form — propane, butane, hexane, and pentane, mixtures of other crude liquid hydrocarbons, and even some crude oil.

At the gas processing plant, these constituents are removed. Some are sent to petrochemical plants for further processing, or to oil refineries to be made into petroleum products. Hydrogen sulfide provides elemental sulfur, most of which is stockpiled. Ethane, propane, and butane serve as raw materials for the petrochemical industries. Propane and butane are also used in residential, farm, and industrial heating.

CORE ACTIVITY

The purpose of this activity is to show that energy conversion wastes can, in some instances, be useful. Remind children of Activities 8 and 12, which dealt with the environmental effects of burning coal to generate electricity and the refining of crude oil to make many useful products. Ask children if they remember what by-products were produced by these conversion processes by asking questions similar to these:

What are the by-products of burning coal?
Fly ash, heat, carbon monoxide, nitrogen and sulfur oxides.

What are the main by-products of refining crude oil?
Hot water used in cooling towers, sulfur, waste gases, sludge.

Write the words *butane*, *ethane*, *fertilizer*, and *methane* on the chalkboard. Ensure that children can read and pronounce each word. Tell children that processing natural gas produces by-products as well. Because this module has not dealt with natural gas, take children quickly through the steps by putting a conversion chart like this one on the chalkboard:

gas, oil separated → gas plant → sulfur removed → water removed → ethane, propane, butane removed → "sweet" gas (methane) sent to homes

Tell children that the main by-products are sulfur, ethane, propane, butane,

and heat. Long ago, most of these by-products were dumped on the earth or burned, causing great damage to the environment. Today, however, many companies are trying to use these by-products. Using by-products helps to protect the environment and earns extra money as well. Elicit from children the uses or possible uses for the by-products illustrated in the flow charts on page 28 of their Student Books. **Sulfur** — fertilizers, pulp and paper manufacturing, matches; **Fly ash** — brick making, pottery making, landfill; **Heated water** — heat for nearby buildings, greenhouses, and swimming pools; **Ethane, propane, butane** — making plastics, other useful products.

Ask children to turn to page 29 in their Student Books. This is a reading on the use of another kind of by-product that otherwise would be wasted. Tell children to read the article, then answer the questions that follow it in their notebooks or on the back of Activity Sheet 11. Possible answers are: **1.** They sprinkle the water on the nearby sand dunes. **2.** Plants have grown on the land. Sheep and cattle now live by eating those plants. The sand is anchored by the plants so that it doesn't blow around anymore. **3.** This is good for the company because they get rid of their waste water and they can now get money for the cattle they can raise. **4.** Power plants that make electricity by burning coal, natural gas plants, and oil refineries.

As a review, have children complete the flow diagram and chart on Activity Sheet 11. When they have finished, have them file the sheets in their energy folders. These are the answers for Activity Sheet 11. **Flow diagram sequence:** crude oil, natural gas, remove sulfur, remove water, remove gas liquids, compress "sweet" gas. **Chart answers: electricity** — P / *Answers will vary;* **fly ash** — BP / bricks, pottery, tiles; **"sweet" gas** — P / heat homes, cooking; **ethane, propane, butane** — BP / plastics, etc., heat farms, factories; **heat** — BP / heat homes, other buildings; **sulfur** — BP / matches, chemicals, paper making; **raw and canned potatoes** — P / food; **potato waste** — BP / fertilize fields.

Activity 17
Decisions, Decisions

OBJECTIVES

43. **Identify possible effects on the environment of some processes used to convert energy from renewable and nonrenewable sources.**
44. **Choose an appropriate course of action according to the analysis of a given situation.**

Preparation Time
Core: 10 min

Extension: 20 min

Oral Vocabulary
none

Instruction Time
Core: two 55-min periods
Extension: 50 min

Reading Vocabulary
decision(s), restaurant(s), tourist

Materials
Each child will need:
Student Book
notebook / pencil

CORE ACTIVITY

Remind children of the major by-products of producing electricity by burning coal and by refining crude oil, and the effects they have on the environment. Remind them that both of these energy sources are nonrenewable. Tell class that conversion of renewable sources of energy can also have an impact on our environment.

Tell children that this activity is an exercise in making decisions on whether a specific kind of energy conversion is right for a particular situation. Explain that it is important for them to consider all aspects of a case before they come to a final decision. They must consider how converting a resource will affect such things as the surface area of the land, the quality of the air and water, all living things, and the supply of the energy source.

Write the words *decision*, *restaurant*, and *tourist* on the chalkboard. Ensure that children can understand, read, and pronounce them. Divide the class into groups of five. Each group will consider the case studies presented on page 30 of their Student Books. Instruct the groups to discuss each situation, make a decision, and record their answers to the questions in their notebooks. Choose one member of each group to act as chairperson, one to record the group's answers and decisions, and a third to present these answers and decisions to the class on the completion of the activity. While the groups discuss the case studies, monitor their discussions in turn to ensure that they understand the issues involved. Make sure that the groups spend no more than about ten minutes on each case study.

Tell children that the groups' findings will be discussed in class on the following day. The ensuing discussion should demonstrate to the class that energy decision-making is a difficult task.

EXTENSION

Energy Decisions in Real Life Have children use the questions from their Student Books to examine a real energy case study taken from reports in your local newspaper. They can do this individually or in their groups. Discuss their decisions in class.

Activity 18
Energy: How We Change It

OBJECTIVES

45. **Review and recall the major concepts presented in this module.**
46. **Recognize that we extend our energy conversion chains by using energy to manufacture consumer goods and process foods.**

Preparation Time
Core: 20 min

Instruction Time
Core: 60 min

Materials
Each child will need:
- Student Book
- notebook / pencil

You will need:
- Filmstrip and cassette, *Energy: How We Change It*
- projector / screen

Oral Vocabulary
none

Reading Vocabulary
none

CORE ACTIVITY

This review unit is built around the filmstrip *Energy: How We Change It.* Since children should be familiar with the concepts presented, a meaningful discussion might be provoked if the filmstrip were run without narration with brief stops for individuals to supply narration. Tell children that this is almost the end of their study on energy and the benefits and problems related to energy. Tell them that, if they pay close attention to the filmstrip, they will be able to do the following review activity without difficulty.

As the filmstrip progresses, review the vocabulary that has been introduced to date by having a good speller put the words on the chalkboard as they come up. You should have your copy of the filmstrip script on hand to make sure that children stay on the right track with their narration. The following are suggested stops and questions for discussion.

Frames 1 – 3

What are the sun's burning gases converted to?
Heat and light energy.
Why are these important forms of energy?
They give life to earth.

Frames 4 – 5

What are two obvious forms of energy?
Sound and motion.
How can we tell that heat and light are forms of energy?
Light helps us see. Heat can cause a change.

Frames 6 – 9

What must we do before we can use energy?
We must convert it to a form we can control.
How did we harness wind and water energy in the past?
To move sailing ships. We used windmills / waterwheels to convert wind / water energy into mechanical energy.

Frame 10

Why weren't wind and water convenient forms of energy?
Wind was not always available when we needed it. Water energy could be used only near its' source.

Frames 12 – 14 **Why is electricity such a convenient form of energy?**
It can be sent long distances to where it is used. It can be converted to heat, light, and mechanical energy to do many useful things.

Frames 15 – 21 **How do we use water energy and the energy stored in fossil fuels to generate electricity?**
Have various children describe the conversion steps for both energy sources as the appropriate frames flash by.
Water: water turns turbine; turbine spins generator; generator produces electricity.
Fossil fuels: burn fossil fuel, heat water to produce steam; steam turns turbine; turbine spins generator; generator produces electricity. The final step in both conversions is transporting the electricity to where it's used.

Frames 22 – 26 **What are some of the benefits of using energy from fossil fuels?**
We use gasoline to get us from one place to another quickly. Oil and natural gas can be used to heat our homes, to produce electricity, and to make other things like plastics. We get a lot of things we need and want.

Frames 27 – 29 **How can we damage our environment when we use coal to produce electricity?**
Warm water used to cool the steam is returned to its source. Burning coal produces smoke pollution and other by-products.

Frames 30 – 31 **Which is more harmful, burning crude oil products or refining crude oil?**
Burning crude oil products.

Frames 32 – 35 **Why is producing electricity from coal an inefficient process?**
It takes many steps to do this. The more steps there are, the more energy we lose along the way.

Frames 36 – 40 **What are some other ways that we use energy from fossil fuels?**
We use it to harvest and process food, to transport various things, and to make many other products.

Frames 41 – 47 **How can we use energy more wisely?**
Drive smaller cars; form car pools; use public transportation; use waste heat to heat buildings; make harmful products less harmful.
Other answers will vary.

Frames 48 – 49 **Why do we need to use energy wisely?**
So we can keep our environment clean and enjoy all the things we get from energy for a long, long time.

Have children turn to page 31 of their Student Books and examine "The Energy in a Carton of Milk" illustration. Remind class that it takes many steps to generate electricity from fossil fuels or to refine crude oil to gasoline and other fuels. Tell class that when we use this energy to process and package foods and make other things, we lengthen our energy conversion chains. Elicit from children that the longer the chain, the more energy we lose. Discuss with children which steps require electricity (manufacturing) and which ones use gasoline and other fuels (transportation). When you have completed the discussion, run the film again with the narration, to reinforce the concepts reviewed.

Activity 19
Cracking the Code

OBJECTIVE **45. Review and recall the major concepts presented in this module.**

Preparation Time
Core: 5 min

Instruction Time
Core: 30 min

Materials
Each child will need:
Student Book
notebook / pencil

Oral Vocabulary
none

Reading Vocabulary
none

CORE ACTIVITY

Children review what they have learned to date by cracking the code on page 32 of their Student Books. Ensure that children understand the directions before they begin.

The code answer is as follows:

1	2	3	4	5	6	7		8	9		10	11	12	13	14	15
S	H	O	R	T	E	R		I	S		B	E	T	T	E	R

The true statements are as follows:

1. There are more than two forms of energy. **S**
2. A heavy object moving at the same speed as a light object has more energy. **H**
3. Noise can be a harmful by-product of conversion. **O**
4. Crude oil and natural gas can be used to make many useful things. **R**
5. The shining of the sun is the first step in a conversion chain. **T**
6. Green plants are the producers in a food chain. **E**
7. Steam generating plants are often built close to where coal is found. **R**
8. Many things must be done to crude oil before it can be used. **I**
9. Gravity makes things fall down. **S**
10. There are more producers than consumers in a balanced food chain. **B**
11. We need to convert energy to a form we can control. **E**
12. North Americans use more oil than anyone else in the world. **T**
13. Most of our pollution comes from the burning of fossil fuels. **T**
14. We need to use energy wisely so we can maintain our way of life. **E**
15. Using long energy conversion chains wastes our nonrenewable energy sources. **R**

Ask children if they can think of another way to solve the code. If no one can, tell them that it can be solved by subtracting two letters from each letter given (C in the code is A, and so on).

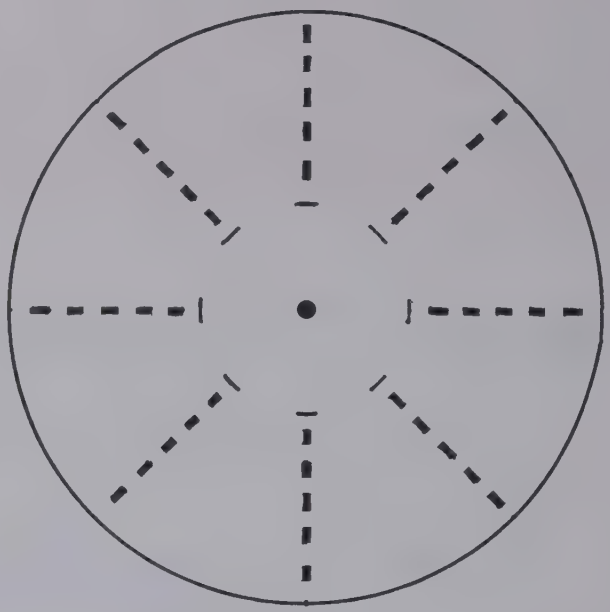
Activity Sheet 1

SEEDS 5

for use with Activity 4

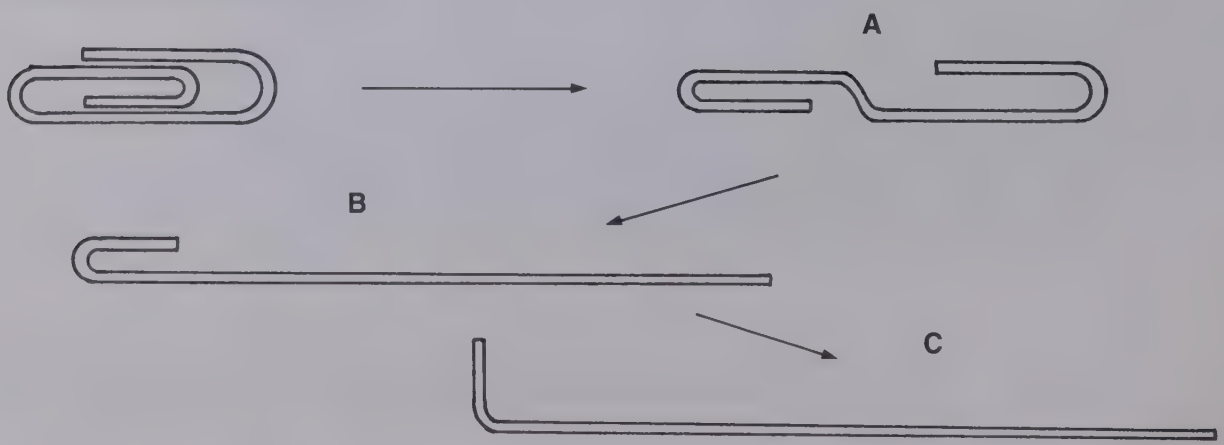
Pattern for Making a Turbine

1. Cut out circle pattern and tape it to pie plate.
2. Cut along each dotted line.
3. Make a small cut on each side of the long cuts.
4. Make a hole for the shaft.



5. For the shaft, cut a piece of drinking straw to this length.

6. Shape your paper clip like this:

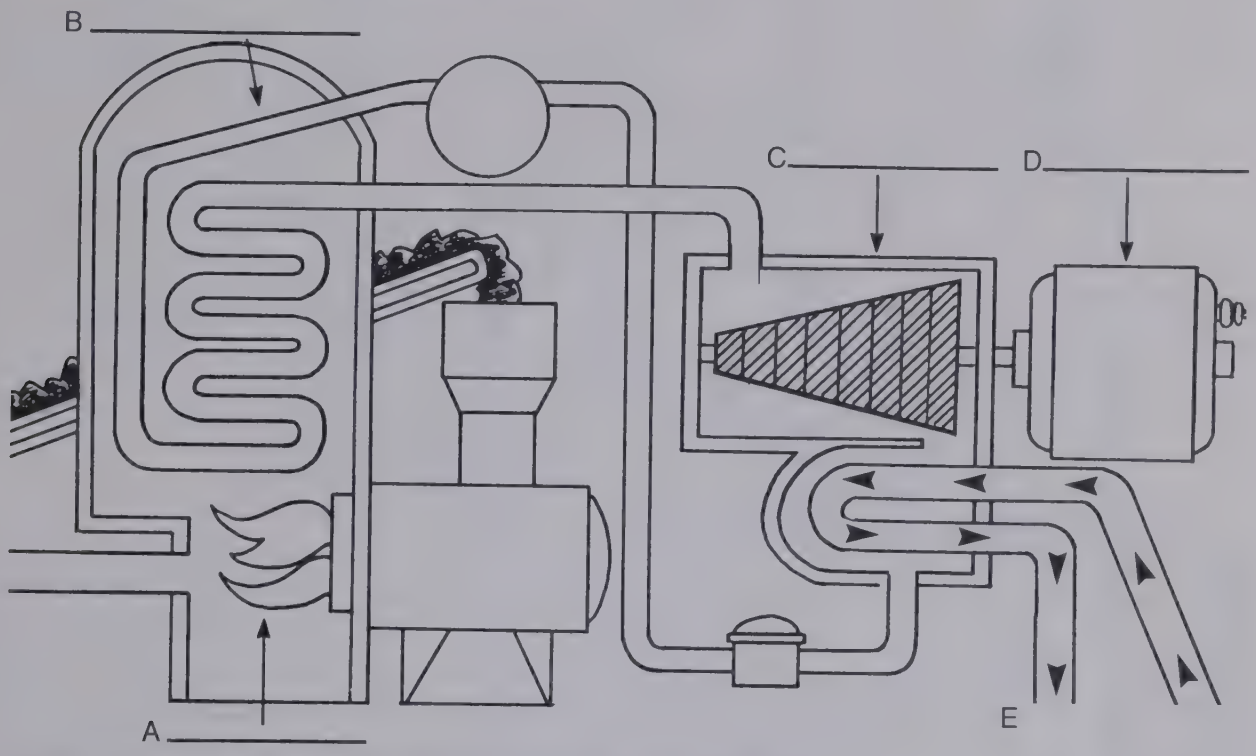


Copyright © SEEDS Foundation, 1981 All rights reserved Permission to reproduce for classroom use.

SEEDS 5 Activity Sheet 2

for use with Activity 5

From Coal to Kilowatts



1. Use a red pencil to trace the path of the steam on this diagram.
2. Use a blue pencil to trace the path of the condensed steam.
3. Write the name of each part beside its letter on the diagram.
4. Describe what each part does.

A _____

B _____

C _____

D _____

5. Complete the picture at E to show how steam is cooled.

Copyright © SEEDS Foundation 1981 All rights reserved Permission to reproduce for classroom use

Activity Sheet 3

for use with Activity 6

SEEDS 5

The Energy Flow in Food Chains

Fill in the boxes with the names listed below.

Be sure you put them in the right order to show how energy flows through food chains.

Part of each food chain has been done for you.

Food Chain 1 (grassland): decomposers, sun, grasshopper, grass, crow

Food Chain 2 (woodland): sun, snowshoe rabbit, decomposer, wolf, willow twigs and shoots

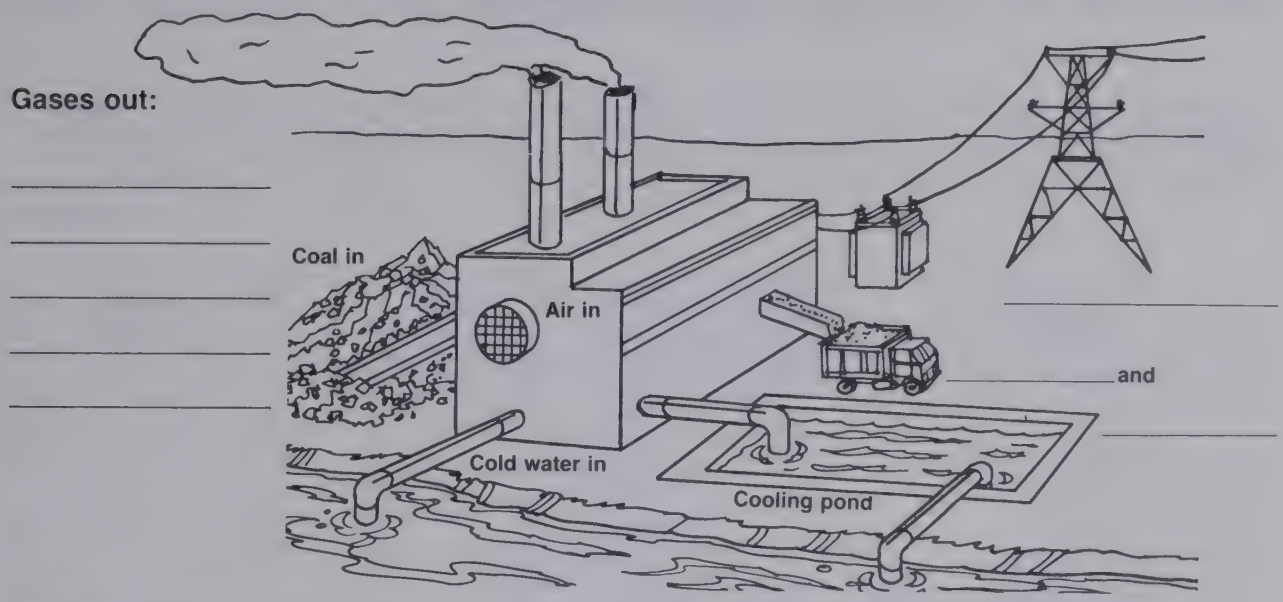
Copyright © SEEDS Foundation, 1981 All rights reserved.

Permission to reproduce for classroom use.

SEEDS 5 Activity Sheet 4

for use with Activity 8

What Goes In and What Comes Out



Write the names for what comes out of a steam generating plant on the diagram.
Use this list to help you.

Complete this chart. Put a check under P for materials that are products or under B-P for by-products.
Write H for materials that are harmful and N for those that are not harmful.
Explain why products or by-products are harmful in the space provided.

Material	P	B-P	Harmful or not?	Why is it harmful?
electricity				
hot water				
coal ash				
fly ash				
water vapor				
nitrogen oxides				
sulfur dioxide				
carbon dioxide				
carbon monoxide				

Copyright © SEEDS Foundation, 1981 All rights reserved Permission to reproduce for classroom use

Activity Sheet 5

for use with Activity 9

SEEDS 5

How We Use Electricity at Home

Look at this list of electrical appliances. Check off each appliance you have in your home. Record the number of hours you think each one is used in a day. Then calculate the electrical energy used in kilowatt hours for each appliance you checked.

	Appliance	Average number of watts	Hours used	Energy used in Kilowatt Hours
	Blender	350 W		
	Toaster	1200 W		
	Coffee maker	900 W		
	Dishwasher	1200 W		
	Frying pan	1250 W		
	Microwave oven	1450 W		
	Refrigerator (frost-free)	600 W		
	Refrigerator (manual defrost)	300 W		
	Food freezer	400 W		
	Stove/Range with oven	12 000 W		
	Waste disposal	450 W		
	Clock	2 W		
	Radio	70 W		
	Television (black and white)	50 W		
	Television (color)	150 W		
	Phonograph/Record player	100 W		
	Iron	1000 W		
	Vacuum cleaner	650 W		
	Sewing machine	75 W		
	Floor polisher	300 W		
	Automatic washer	500 W		
	Clothes dryer	5000 W		
	Room air conditioner	1000 W		
	Fan (window)	200 W		
	Shaver	15 W		
	Hair dryer	400 W		
	Water heater	2500 W		

Copyright © SEEDS Foundation, 1981 All rights reserved. Permission to reproduce for classroom use.

How We Use Electricity at School

List six electrical items and where they were located. Record the number of watts and hours used for each item. Calculate the electrical energy used in kilowatt hours. Remember, multiply the number of watts by the number of hours used and divide by one thousand to get kilowatt hours. Then calculate how much it cost to use each item.

Electrical item	Where was it?	Number of watts	Hours used	Energy used (kilowatt hours)	Cost
			Total		

1. a) Which item in the school used the most electrical energy?
   b) How much did it cost to use this item?
2. a) Which item used the least energy?
   b) How much did it cost to use this item?
3. a) Which item was used for the longest time?
   b) Did it use the largest number of kilowatt hours?
4. a) How many kilowatt hours of electricity did all six items use?
   b) What was the total cost?

Copyright © SEEDS Foundation. 1981 All rights reserved Permission to reproduce for classroom use

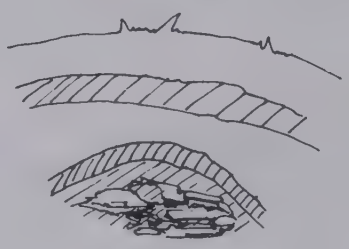
Activity Sheet 7

for use with Activity 11

SEEDS 5

From the Well to the Car

Write each phrase or word where it belongs on the drawing.



1_____

_____

_____

2_____

_____

_____

railway, pipeline, or tanker

tower

treated and blended

sun shone, plants and tiny animals lived

tank

natural gas

pump

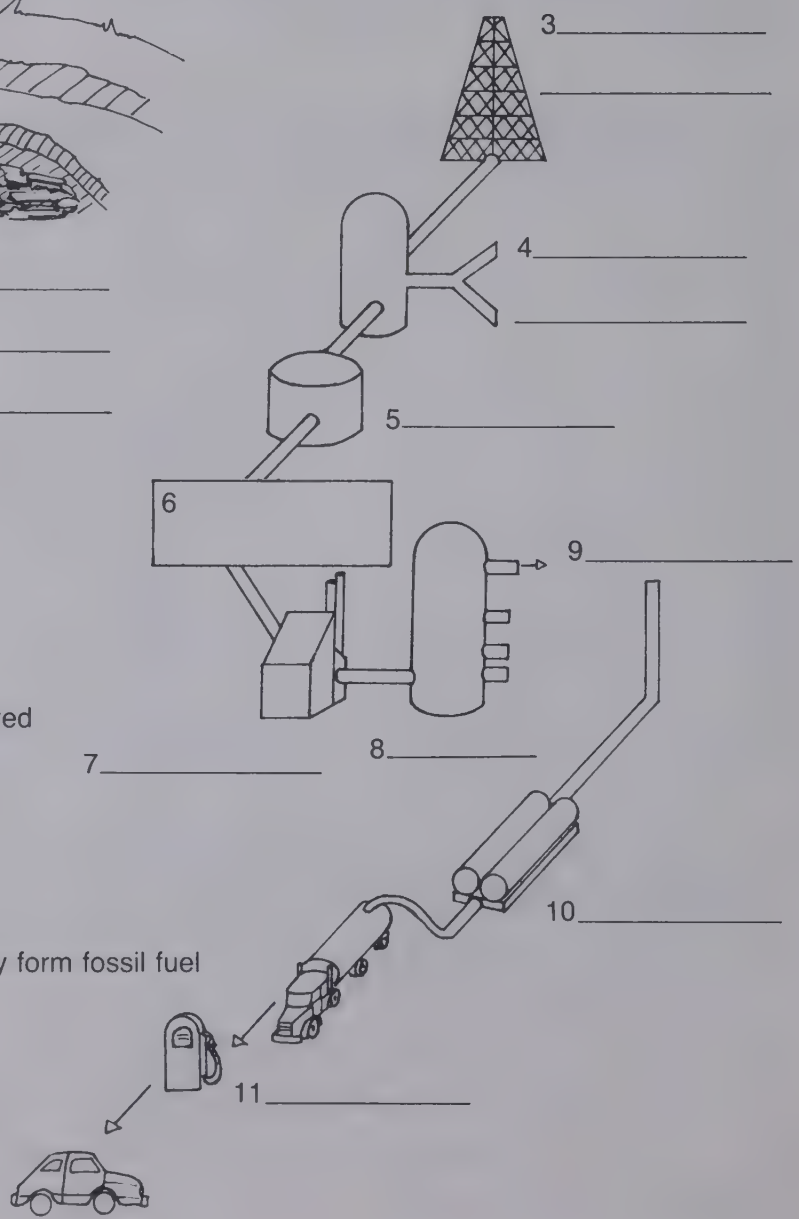
plants and tiny animals die, eventually form fossil fuel

raw gasoline

furnace

crude oil from well

water

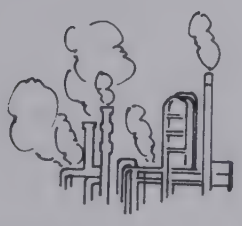


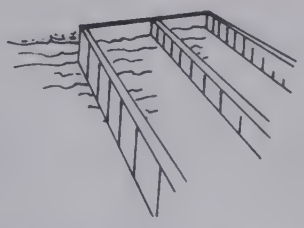
Copyright © SEEDS Foundation, 1981 All rights reserved.

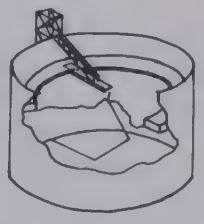
Permission to reproduce for classroom use.

Oil Refining and Our Environment

1. Complete this chart. Put a check under YES for the by-products that are harmful or under NO for those that are not. Explain what refineries can do to make the harmful by-products less dangerous.







By-product	Harmful?		What do refineries do?
	YES	NO	
warm water			
waste gases			
steam, water vapor			
sulfur			
water for treating			
substances that evaporate			
carbon monoxide			
sludge			
oil from settling pond			

2. Which energy conversion is more harmful to our environment — oil refining or electricity produced by burning coal?
3. Which causes more pollution, using electricity or using oil?

Copyright © SEEDS Foundation. 1981 All rights reserved Permission to reproduce for classroom use

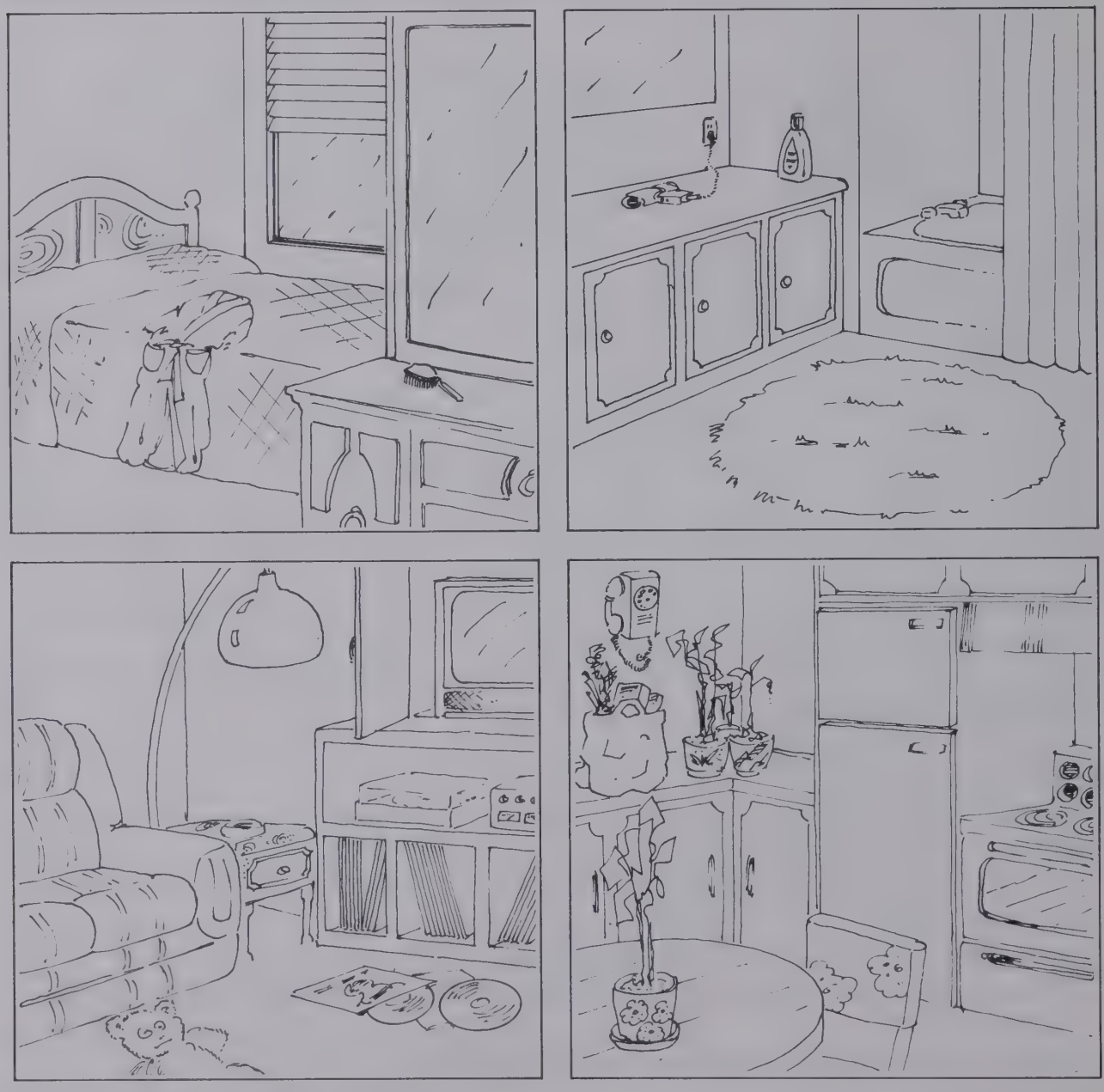
Activity Sheet 9

for use with Activity 13

SEEDS 5

Our Plastic World

Shade in all the things that are made from crude oil.



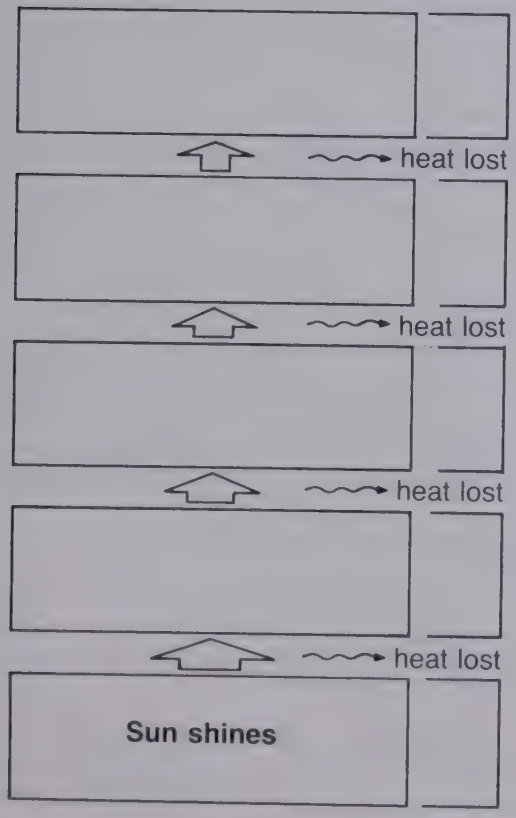
Copyright © SEEDS Foundation, 1981. All rights reserved. Permission to reproduce for classroom use.

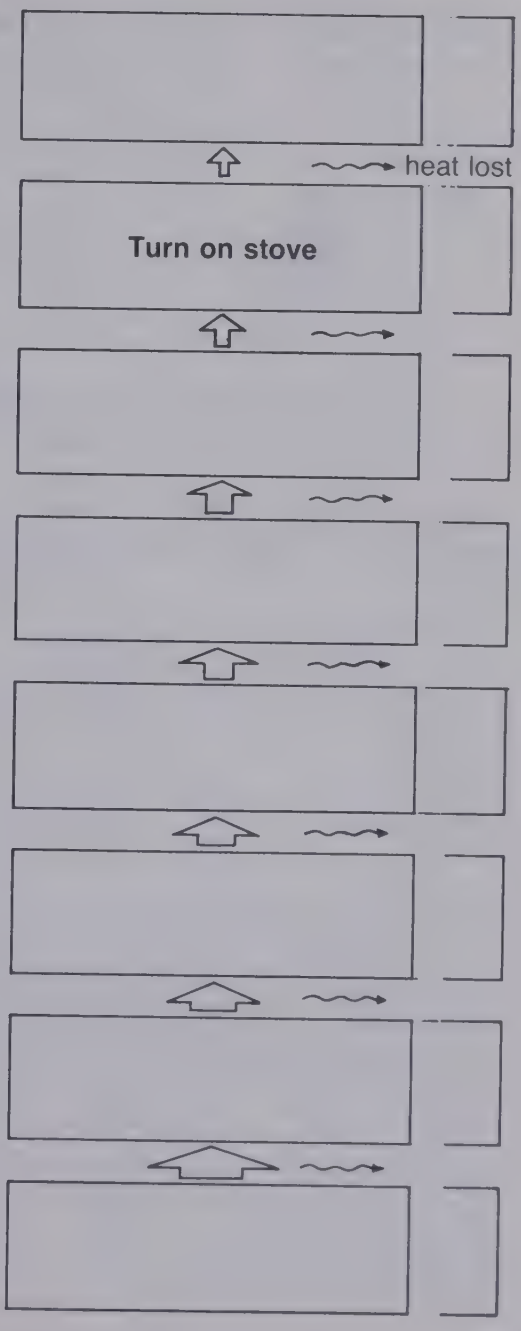
The Long and the Short of It

Complete the short conversion chain, then the long one. Fill in the boxes with the phrases listed. Be sure to put the phrases in the right order.

Short Chain: Cooking Food over Campfire
– set logs on fire; sun shines; chop down tree and cut into logs; cook food over campfire; trees grow

Long Chain: Cooking Food on Electric Stove
– coal formed; cook food on stove; plants grow and die; electricity sent to home; coal extracted; sun shines; turn on stove; coal burned to generate electricity





Copyright © SEEDS Foundation. 1981 All rights reserved
Permission to reproduce for classroom use

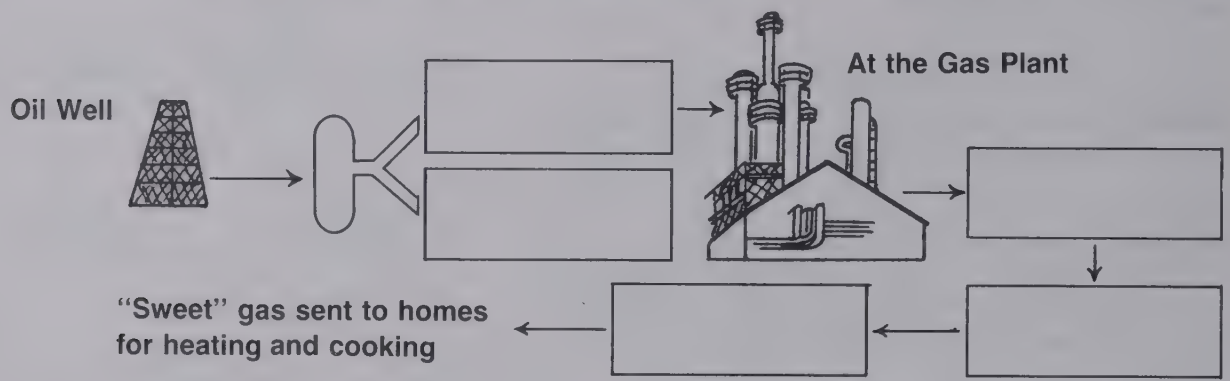
Activity Sheet 11

for use with Activity 16

SEEDS 5

Use It If You Can

Fill in the boxes on the diagram with the following words or phrases: remove water; crude oil; remove sulfur; gas; natural gas; remove gas liquids. Be sure you put them in the right order.



Complete this chart. Put a check under P for materials that are products or under B-P for by-products. Use the space provided to explain possible uses for the by-products and how the products are used.

	Material	P	B-P	Use or Possible Use
Coal	electricity			
	heat			
	fly ash			
	sulfur			
Natural Gas	"sweet" gas			
	sulfur			
	ethane, propane, butane			
	heat			
Potatoes	raw and canned potatoes			
	potato waste			

Copyright © SEEDS Foundation, 1981 All rights reserved

Permission to reproduce for classroom use.

SCRIPTS FOR SOUND FILMSTRIPS

Energy: The Sun

1 Our sun is full of energy. It's a ball of very hot burning gases.

2 They are actually exploding and giving off — releasing — heat and light energy.

3 The light and heat energy are so powerful that they travel all the way from the sun to the earth. But just what is energy?

4 Energy is force and movement. Where does it come from?

5 A jet plane gets its energy to move from jet fuel.

6 Gasoline gives this school bus energy to move.

7 And food gives us the energy we need to move — and to grow.

8 We get energy from eating foods such as fruits and vegetables.

9 But where do plants, these fuels for people, get their energy?

10 The sun gives plants light and heat energy to help them grow.

11 Some of this energy is stored inside plants. So, we call it stored energy.

12 Trees are a good source of stored plant energy.

13 When we burn wood, we release its stored energy. This energy is called biomass energy. Wood is a source of biomass energy that gives us heat and light.

14 The wind is another source of energy. We use it sometimes to move things.

15 The force of moving water is also a source of energy. Both water and wind energy are made by the sun.

16 Wind is made by the sun's uneven heating of the earth's surface.

17 You can feel the difference in the heating of various surfaces when you walk barefoot on hot sand or on cooler grass.

18 The air above different materials such as rock, water, or trees heats at a different speed — some quickly, some slowly.

19 Air moves from higher to lower temperatures. This moving air is called wind. The sun's heat energy makes rain, too.

20 The sun's heat makes the water in lakes, rivers, and oceans dry up, or evaporate, into the air. Like the wind, water vapor is invisible.

21 When clothes are dried by the sun or in an automatic dryer, the same thing happens. Water is evaporated into the air.

22 As the vapor rises, it gets colder, condenses, comes together again, and forms clouds. Later the water falls from the clouds as rain or snow.

23 When people have a shower, the same thing can be seen. Water from the shower evaporates. When it touches the cold surface of the mirror, it cools and condenses, forming water drops.

24 Some streams and rivers are formed by rain and snow. They flow into lakes and oceans. The flowing water is our source of water energy.

25 Years ago, people used water and wind energy in waterwheels and windmills to grind grain.

26 Water energy was also used to cut lumber.

27 But in pioneer times, people most often used the muscle power of animals, or their own muscle power, to get jobs done.

28 Today we use much more energy because our population has grown, and we have to grow more food to feed many more people.

29 We use electrical energy to grind grains and to make bread.

30 We use electricity to process foods, and to make the containers to keep foods in until we eat them.

31 And we use gasoline fuel to move from one place to another.

32 Many homes are heated by oil or natural gas, and some by coal. Where do these energy sources, these fuels, come from?

33 They come from the sun's energy stored in plants and tiny animals that lived millions of years ago.

34 When they died, these plants and animals fell into swamps and were covered with mud. Over millions of years, the mud layer grew thicker and thicker.

35 As the plants and tiny animals were pressed by the mud, they gradually became coal, oil, and natural gas. These are called fossil fuels.

36 We remove fossil fuels from the ground, and we use them in many different ways.

37 Coal, oil, and natural gas are used to make electricity.

38 Electrical energy in our homes gives light and heat . . . for cooking and warmth.

39 Many manufacturing companies use electricity to make their products.

40 We own and use many plastic items that are made from natural gas and oil.

41 Gasoline comes from oil. In many ways in our daily life, we depend on energy from fossil fuels, sunshine buried long ago.

42 Once we use fossil fuels, they are gone forever. They cannot be renewed or used again. They are nonrenewable. So, we must use them wisely.

43 Since the manufacture of some containers and other products uses a great deal of energy, we should recycle or reuse these whenever we can.

44 We should also use energy in ways that cause the least damage to our environment — our air, water, plants, and wildlife.

45 We need energy every day. We need electrical energy to process foods and to give us light and heat in our homes.

46 We need oil, natural gas, and coal — the fossil fuels — to heat our homes.

47 And we need gasoline for transportation. But our supply of fossil fuels is running out.

48 We should make more use of our renewable energy sources, such as wind energy.

49 With modern wind generators, electricity can be made for use in homes or on farms.

50 And solar energy can be used to heat our homes, or heat water for home use.

51 In future we should try to make more direct use of the energy source that we depend upon the most . . .

52 . . . the most powerful, longest-lasting, renewable energy source we know.

Energy: How We Change It

1 Our sun's hot gases are constantly burning.

2 They burn with such explosive force they are converted into light and heat energy.

3 The powerful light and heat energy that travel far out into space give life to the earth.

Heat and light are just two forms of energy. There are many other forms.

4 Sound and motion energy are obvious forms of energy we hear and see every day.

5 We know we get heat and light energy from the sun each day, but we don't always notice their presence and what they can do.

6 We can see electrical energy in the form of lightning. But, like other forms of natural energy, we must control or harness it, to make use of it.

7 For many years we have harnessed wind energy to move sailing ships from one place to another.

8 And we have harnessed the energy of flowing water with a waterwheel.

9 Water energy provides the power that turns the main wheel outside, which, inside, turns the gears and grinding stone. In this way, water energy is converted to mechanical energy.

10 However, wind energy is not always available when we need it. And we can use water energy only near the water; without conversion, it can't be transported to our homes, farms, or businesses.

11 Electrical energy can be produced — generated — by the force of a turning wheel.

12 And we can transport it to where we use it. In a hydroelectric generating station, the energy of falling water is converted to electricity. It is transported to homes and factories far away.

13 Electricity is a convenient form of energy, available when and where we want it. We use it to do many things.

14 Electricity runs complicated business and manufacturing machines. Yet, it's produced by a simple method.

15 In a hydroelectric station, water falls down a long tube and turns a turbine with tremendous force.

16 The turbine spins a generator which produces electricity. The electricity is transported to us by power lines and towers. Hydroelectric generation is just one method of producing electricity.

17 Coal, oil, natural gas, or uranium, can be used to produce electricity. These fuels are burned to provide the heat energy which drives turbine generators. It takes several steps to do this.

18 The heat energy is converted to mechanical energy, and then to electrical energy. In this case, burning coal heats water, turning it into steam.

19 The force of the steam spins the turbine generator, producing electricity.

20 The steam is cooled, condenses into water again, and returns to the boiler to continue the cycle.

21 Electricity is transported to our homes, providing us with light and heat energy. It's a clean source of energy.

22 To transport ourselves and our products, we rely on the conversion of gasoline to mechanical energy.

23 The gasoline we use comes from a fossil fuel — oil. Fossil fuels provide us with many benefits.

24 Much of our electricity is produced by burning fossil fuels.

25 Electricity lights up our cities and supplies needed power to hospitals.

26 It also provides us with the power to run the appliances we choose to use. However, although electricity is a clean energy to use, sometimes it's produced by polluting methods.

27 Thermal-electric generating stations discharge into lakes and rivers a lot of the water that was used to cool the steam.

28 This water, now warmer than its original source, changes the environment of the lake or river.

29 Burning coal to generate electricity produces smoke pollution.

30 Converting gasoline to mechanical energy also damages our environment. The exhaust fumes from our cars cause a tremendous amount of air pollution.

31 Oil refineries sometimes pollute our air. And their waste water, containing excess heat and chemicals, damages our water and its plant life, water-fowl, and fish life.

32 Also, converting fossil fuels to electricity requires several conversion steps, and uses a lot of energy along the way.

33 Energy is used to extract coal — another source of energy — from the ground.

34 And energy is used to transport it from the coal mines to generating stations to be converted to electricity.

35 After all these conversion steps, only about 40% of the coal energy becomes electrical energy — 60% is lost.

36 Yet today, to maintain our health and well-being, we depend on the convenience of energy that has been converted from fossil fuels.

37 The harvesting of our food depends on energy converted from oil.

38 Gasoline or diesel fuel supplies energy for transporting foods and other products.

39 Electricity, converted from coal, oil, or natural gas, provides the power to process and package foods. But these are fossil fuels, nonrenewable sources of energy.

40 We must try to use fossil fuels more wisely, and convert them more efficiently, and in ways that are safer for the environment.

41 We can drive smaller cars which use less gasoline but give the same efficient conversion.

42 And we can use gasoline energy more wisely by forming car pools to travel to group activities.

43 And some people will drive small electric cars, especially for short-distance trips.

44 And, naturally, we can save gasoline by traveling on public transportation whenever possible.

45 We can use the heat usually discharged as waste by oil refineries to grow plants or heat buildings.

46 Refineries can avoid polluting water, by removing heat and chemicals from waste water before they discharge it.

47 And, to meet our needs, we should try to convert energy in ways that help maintain a healthy, natural environment.

48 Our world is a wonderful place to live in. It's up to us to keep it that way with a clean environment, clean air, and water.

49 We can do this and still enjoy the benefits that fossil fuels give us, if we use them wisely.

NOTES:

SEEDS

The Energy Literacy Series

Professional Reference Guide

Levels 1 to 6

SRA

SCIENCE RESEARCH ASSOCIATES (CANADA) LIMITED

Toronto, Montreal, Chicago, Palo Alto, Sydney, Henley-on-Thames

SEEDS Foundation

EXECUTIVE DIRECTOR: Robert Westbury

PROGRAM DIRECTOR: Hugh Phillips

SRA

EDITORIAL TEAM: Judith Reeves-Stevens, Karin Velcheff, Joe Sobura, Sherry Henderson

WRITER-CONSULTANT: Elma Schemenauer

PRODUCTION COORDINATOR: Shelagh Roberts

DESIGN: Henning Christensen Graphics

ACKNOWLEDGMENTS:

Every effort has been made to identify and credit appropriately the sources of all copyright material used in this book. Any information concerning perceived errors or omissions will be appreciated, and the correct source acknowledged in subsequent editions.

Page 5 *Energy Education: Goals and Practices.* "Justification of Energy Education" by Rodney F. Allen. © 1980, Phi Delta Kappa Educational Foundation. Reprinted with permission from Phi Delta Kappa Educational Foundation and Rodney F. Allen.

Copyright © Society, Environment & Energy Development Studies Foundation, 1981.
Published by Science Research Associates (Canada) Limited.
All rights reserved. Printed in Canada.

No part of this publication may be reproduced or transmitted in any form, including any storage or retrieval system, or by any means, electronic, mechanical, photographic, or recording, without permission in writing from the publisher.

Printing History

9 8 7 6 5 4 3 2 1 81 82 83 84 85 86 87 88 89 90

Reorder No. 3-280400 **ISBN 0-574-09400-8**

CONTENTS

Introduction 5

Definitions and Concepts 7

Content Summaries 9
- Level 1 9
- Level 2 9
- Level 3 10
- Level 4 10
- Level 5 11
- Level 6 11
- Additional Investigations 11

Core Objectives and Skills 13
- Method of Listing Objectives in SEEDS 1—6 13
- Energy Literacy Objectives Chart 14
- The Cognitive Objectives 24
- Learning, Thinking, and Valuing Skills Chart 25
- Process Skills Chart 34
- The Attitudinal Objectives 35

Integrating SEEDS with the Elementary Curriculum 36
- Relationship of SEEDS to Science, Social Studies, and other Subject Areas 36
- Practical Suggestions on Scheduling and Timetables 37

Teaching Strategies Used To Present and Develop Concepts 38
- The "Guided Discovery" Approach 38
- Questioning and Class Discussion 39
- Story Approach in SEEDS Levels 1—3 39
- Group Activities 40
- Community-based Activities 40

Review and Evaluation 42

Materials 43
- Materials Found within the Program Itself 43
- Concrete Materials To Accompany the Program 43
- Printed Materials as a Resource for the SEEDS Program 44
- Audio-visual Materials for SEEDS 1—6 45
- Choosing Supplementary Audio-visual Materials 48
- Using Audio-visual Materials 48

Introduction

The SEEDS materials have been designed for use either as an energy unit in a core science or social studies curriculum or to stand on their own as an energy curriculum. The Teacher's Guides for each level of the SEEDS program present strategies and techniques for the *how* of teaching the program's energy literacy concepts and skills. This Professional Reference Guide provides a comprehensive view of the *what* and the *why*. The cross-level content development, the spiral pattern of expanding concepts, the learning / thinking / valuing skills, and the progression and interrelationship of objectives and skills from level to level are summarized in subsequent sections and in the charts on pages 25–33 and pages 14–23. However, it is important at this point to restate the original motivation and rationale for the program.

Robert Westbury, Executive Director of the SEEDS Foundation, summarized the history of the Foundation and the development of the Curriculum Project in a brief Preface at the beginning of each Teacher's Guide. Two statements bear repeating here: The primary goal of the Foundation—"to encourage the development of an energy-literate society, a society concerned about and committed to the wise use of energy"; and the rationale for the educational modules that comprise the Curriculum Project—"to help young people develop informed views on energy and the environment and act on them."

In the process of preparing the material for publication, Dr. Westbury was intrigued to find that another concerned educator, Rodney F. Allen, had independently compiled the following list of "justifications" for energy education in the booklet, *Energy Education: Goals and Practices*, published by the Phi Delta Kappa Educational Foundation in 1980:

"*Educated Citizenry Justification:* A basic premise of democracy is that citizens with adequate skills and knowledge participate in making the decisions that affect them. Solutions to energy problems require a knowledge of, and participation in, the political process. Traditionally, education has served to equip citizens with the knowledge and skills needed to make such decisions and to take action.

"*Economic Justification:* Energy education is needed so that citizens may make rational choices in their personal lives about public policy questions.

" '*Doing Good*' *Justification:* Energy education offers the opportunity to create a more just and humane society. It can provide the re-educative process that will lead to a more environmentally sound lifestyle and a more equitable distribution of goods and services in the national and world community.

"*Problem-Solving Justification:* Solving widespread energy and environmental problems can be undertaken by a well-educated citizenry. Since energy is so directly related to the conditions that sustain life and give it meaning, educational programs are needed to provide the techniques for solving the energy crisis.

" '*Take Care of Self*' *Justification:* Energy education can teach people how to conserve energy and to make decisions to optimize their personal resources and well-being. Such learning will build personal responsibility and will help to protect personal effects.

"*Educated Person Justification:* Society is beset with technological problems about resource use that require educated and inquiring minds. Energy education should be part of general education now and in the twenty-first century. A sound knowledge of energy concepts and issues should be expected of all educated people.

"*Career Education Justification:* Many of today's students will find careers in energy industries (e.g., solar installation, energy audits, and energy-efficient construction) or in industries that depend on crucial energy decisions. Schools have a role in preparing students for these and other careers.

"*Stewardship Justification:* Energy education, like environmental education, offers an opportunity for persons to learn a "common good" ethic, where the well-being of all people (including those yet unborn) is taken seriously in resource use and in the allocation of goods and services. If everything is connected to everything else, we need to learn those relationships and to use them. The

welfare of all and responsibility to the posterity of our nation are central themes in this argument.

"*Apocalyptic Justification:* We must learn the wise use of energy resources since there is such a limited supply of nonrenewable energy resources. National survival and the well-being of the world community depend upon effective and equitable use of energy to ward off resource depletion on the one hand and environmental disaster on the other. We need people who can stand at Armageddon and do battle for our survival.

"Whether or not one concurs with all of the justifications offered here for energy education programs in the schools, learning about energy is essential for the social education of all children whose lives will extend well into the twenty-first century. In responding to dwindling energy supplies, our technological advances may be spectacular. Legislation may force us into immediate conservation efforts. Pricing mechanisms may cause life-style changes. But in the long run, it is the knowledge, abilities, and personal commitments of the people in a free society that will permit successful responses to the energy crisis."

The Foundation does not claim such all-encompassing justifications for either its own existence or the curriculum materials, but interwoven in its name are the three topics that recur in the descriptions above—Society, Environment, and Energy. The main ideas grouped into these three strands evolved from the preliminary content analysis undertaken by the educators for the preparation of the curriculum materials.

The main ideas provide the broad organizing concepts, drawn from the social sciences, the natural sciences, and the physical sciences, that recur from level to level throughout the program. They are presented within different contexts and with gradually increasing complexity as the students progress. The process of concept-learning is inherent in the specific objectives, stated in terms of learning outcomes expected for the students.

We have used the term "energy literacy" to describe this process designed to lead to the development of informed views on energy and the environment. But the objectives also reflect the behavioral goals of changing one's attitude, of taking action on a personal level and in related social issues, of conserving energy where possible, of wisely *using* rather than *abusing* our natural resources.

Definitions and Concepts

In developing the main concepts from the social, the natural, and the physical sciences, the presentation in the student materials has been written to the level of the average student's understanding. This has, at times, necessitated the simplification of explanations or definitions. For example, the statement "energy is the ability to do work," while satisfying to scientists, is only puzzling for most young students. Children can more easily gain an appreciation of the meaning through activities and experiences that broaden their understanding.

For more capable students, more detailed definitions or explanations should not be avoided. But all children should be encouraged to continue testing, exploring, investigating, and discussing observations until they can give a satisfactory explanation in their own words. At that point, the name for a concept or the accepted definition can be provided by the teacher.

For this reason, we have provided some background information for teachers who may not have a full command of the concepts dealt with in the program. These Teacher Background sections are provided to reduce the need for teacher preparation. However, there is no substitute for in-depth teacher preparation and practical investigation since both teachers and students benefit from the processes of investigating, hypothesizing, and testing in order to gain a better understanding of how our world functions. Teachers should be aware that the following topics in particular have been presented in a simplified form consistently in all components of the elementary levels: the definition of energy, the definition of solar energy, the description of energy flow on earth, and the definitions of "renewable" and "nonrenewable" as applied to sources of energy. For teachers who feel that their students can benefit from a more technical explanation of these topics, the following essay should prove helpful.

Energy is a quality or state of an object or set of physical circumstances. Energy can be thought of as the source of all activity in the physical world. Physical phenomena represent transformations or exchanges of energy. Thus, the classical definition of energy as "the ability to do work" reflects the difficulty we have in defining it as a concrete, physical entity. We tend to quantify and describe energy in terms of what it can *do* rather than what it *is*.

On earth, our main source of energy is the sun which is a middle-aged star, about four and one-half-billion years old, that has not yet exhausted its hydrogen fuel. Spectral analysis of the sun's light and other astronomical data indicate that about three-quarters of the sun's mass is hydrogen; about 20% or more is helium; and the remainder is composed of traces of elements like carbon, nitrogen, oxygen, magnesium, and silicon.

Using information gained partly by observation and partly by theoretical models, scientists have described the sun as composed of various layers: the *core* where thermonuclear reactions occur; the *convection zone;* the *photosphere* or deepest visible layer; the *reversing layer;* and the *atmosphere,* composed of the *chromosphere* and the *corona.* The atmospheric layers may have temperatures of over 1 000 000°C but the photosphere is only about 6 000°C. From the photosphere inwards, the temperatures, pressures, and density of material increase dramatically. The temperature of the core is about 20 000 000°C. At the temperatures and pressures encountered near the center of the sun, only the most elemental forms of matter can exist—atomic nuclei must be nearly stripped of their electrons. *Plasma* is the term used to describe this "fourth state of matter" which is not solid, liquid, or gas.

The sun is like a gigantic hydrogen bomb generating energy in its core at a prodigious rate. It is believed that four hydrogen nuclei fuse to form one helium nucleus, subsequently releasing energy in the process. It has been estimated that some 597 000 000 t of hydrogen fuse to form 593 000 000 t of helium every second. Because of the vast quantity of hydrogen present, the sun will continue producing energy at this rate for billions of years. As the hydrogen supply becomes depleted, and the sun's composition becomes less homogeneous, another set of nuclear reactions may cause the sun's luminosity and size to increase so much that the earth will boil away. However, this may occur some four and one-half-billion years hence.

The energy released in the sun's core is transported to the surface by a combination of radiation

and convection. *Convection* is the transmission of heat energy by the physical movement of material; *radiation* is the transmission of energy by photons. Radiation dominates in the interior regions and convection in the outer quarter of the sun's radius, terminating just below the photosphere. In the photosphere, radiation takes over completely. The earth's upper atmosphere receives only about one two-billionth of the sun's radiant energy. About 30% of this is reflected back into space. The remaining portion warms our planet, generates the ocean currents, drives the local and global wind and water cycles, and sustains life.

Only about 0.03% of the incident solar radiation is captured and converted into organic matter by green plants through the process of photosynthesis. Much of this material will eventually decay and thus release its stored solar energy. Over the last six hundred million years or so, a very minute fraction of organic matter has been deposited in oxygen-deficient environments and thus has been preserved in the form of fossil fuels—the so-called nonrenewables. Other sun-dependent energy sources, such as wind, water, and biomass, have been classified as the renewables.

The classification scheme for determining whether or not a particular energy source is renewable or nonrenewable depends on how one wishes to interpret the factors considered in the definition, such as the type of source, the amount present, its rate of consumption, and / or rate of formation, as well as the time scale being dealt with. The fossil-fuel stock is being replenished through processes similar to those that created it in the past, yet at about the same rate as in the past. Thus we could argue that the term "nonrenewable" is inappropriate. But, fossil fuels are being consumed at a far greater rate than their present rate of formation. In several centuries, they may not be available for us to use, but several million years from now, they may possibly be available again.

A similar argument can be developed for biomass energy from trees. We can say that trees replace themselves (reproduce) in a relatively short period of time. Thus, they are a renewable energy source. Yet if the rate of consumption outpaces the rate of replacement, this source of energy effectively becomes nonrenewable. Even the most important source of energy, the sun, will eventually "burn up." Thus, the definitions of renewable and nonrenewable, as well as their applicability, tend to become less clear and may even break down under close scrutiny. For the sake of convenience, the terms renewable and nonrenewable are used to simplify relative comparisons between energy sources for discussion in terms of the everyday world we live in.

The elementary levels of the SEEDS program develop the following major concepts.

1. Our earth is a self-sustaining, self-contained life-support system composed of a large number of environments, or ecosystems.

2. All living things fit into a complex pattern of interrelationships and interdependencies known as food chains.

3. People, as well as all other living things, affect their environment and are in turn affected by it.

4. The sun is the earth's most important source of natural energy.

5. People have in the past freed themselves from a way of life dependent on their own muscle-power and the muscle-power of any animals they were lucky enough to own by using energy from various sources. Modern civilization, and ultimately life itself, will continue only as long as adequate energy sources are maintained.

6. People must change their ways of living to fit changing conditions.

7. The principle of balance is a key to the understanding and wise use of resources.

8. If a natural environment is undisturbed by human beings, it tends to move to a state of equilibrium, or balance.

9. Human beings must disturb the natural balance in order to satisfy their energy needs. However, they should try to establish a new balance, whenever they can. This new balance should be one that supplies their needs while still maintaining the factors that create the needed resources.

10. Individuals should develop sets of values that balance future needs against immediate gains, and social good against private advantage.

Content Summaries

Level 1

The first level of the SEEDS program begins with a consideration of human energy. By performing specified actions, the children learn that energy is what allows people to move. They also discover that some actions use a lot of energy, others only a little. They then classify activities by the amount of energy required to perform them. Then they learn that animals, like people, have energy and that both people and animals eat food to get their energy.

As the activities progress, the children are led to realize that machines use energy too—but their energy comes from other sources, such as electricity and gasoline.

The children then investigate the source of our energy—plants. They learn by experimentation that plants need sunlight, soil, water, and air in order to live and to grow. This leads to a brief discussion of the water cycle and the sun's role in it.

Next the children learn to differentiate between things that are alive and things that are not alive. This leads to a discussion of food chains and how all things interact within environments. This in turn leads to a discussion of how the use of energy—particularly energy from oil and gas—can harm our environment and why we must use energy wisely to make our energy sources last as long as possible and also to protect our environment from the pollution caused by using certain forms of energy.

Level 2

The second level of the SEEDS program begins with a brief recapitulation of important ideas presented in Level 1, with an emphasis on the nature of energy and the importance of the sun as the major source of energy.

From this introduction, Level 2 moves on to an examination of natural environments as opposed to environments that have been largely made by people. The natural environments are balanced, in that energy sources are continually being renewed and are seldom "used up" completely. By contrast, energy sources in environments created by people are used up and must be replaced from outside sources.

Level 2 introduces renewable sources of energy: wind, water, and wood—all of which depend upon the most important source of all, the sun.

The study of wind begins with a definition of wind as moving air. The children observe how moving air does work by seeing how a fan blows pieces of paper about and how curtains move in a breeze. A teacher demonstration with a candle and aluminum-foil strips is used to show the children how the sun causes wind by warming the earth's surface unevenly. Warm air rises and cooler air rushes in producing wind. Children go on to define ways in which people can use wind energy at home, in school, and in the community. They learn that, whenever we can, we should use wind energy in preference to energy derived from nonrenewable sources.

Next, they learn that moving water is another important renewable source of energy. The children themselves perform an experiment to show that moving water has energy. This source of energy comes to us ultimately from the sun since the sun's heat is the moving force in the water cycle. Children discover that people can use energy from moving water in a number of ways, the most important of which is the generation of electricity.

The children then learn that trees are a third important renewable source of energy. They provide us with food energy in the form of nuts, fruit, and so on. Through a teacher demonstration the children feel and see that we also get heat and light energy from burning wood. They learn how wood energy comes ultimately from the sun and that we should use wood energy wisely since trees take a long time to grow to maturity. The children learn to recycle paper as one way of using wood wisely.

The central theme of Level 2 is that using renewable energy sources is preferable to using nonrenewable sources. However, this is not always practical or easy to do. Often the source of energy is not there when we want it. For example if the

wind is not blowing, we cannot use wind energy to move a sailboat. Also, renewable energy sources are sometimes difficult to control. They can even be destructive; as, for example, the wind energy in a hurricane or tornado, the water energy in a flood, or the wood energy in a forest fire.

Level 3

The third level of the SEEDS program begins with a brief recapitulation of important ideas presented in Levels 1 and 2—the nature and sources of energy, the distinction between renewable and nonrenewable energy sources, and the basic concept of conservation (using wisely).

From this introduction, Level 3 moves on to a study of three important nonrenewable sources of energy—coal, oil, and natural gas.

By reading a short passage in their Student Books, the children learn why coal, crude oil, and natural gas are called *fossil fuels*. They learn that fossil fuels are energy from the sun stored in the bodies of plants and microscopic animals that died millions of years ago. In the case of coal, woody green plants were the material that gradually—with time, heat, and pressure—changed into a fossil fuel. Crude oil and natural gas were formed by a similar process from the bodies of plants and tiny animals that lived in the sea. Oil sand is the name given to a solid mixture of crude oil and sand.

Then the children learn that the solid fossil fuels, coal and oil sands, are extracted from the earth by mining. Strip mining and shaft mining are the methods for coal, depending on the location of the coal seams. Crude oil is a liquid fossil fuel. Natural gas is found in a gaseous state. Both are extracted from the earth by drilling. By experimenting with a model, children discover how both mining and drilling can affect the environment. They then identify and evaluate some good and bad effects of these extraction processes.

Fossil fuels must be changed and prepared in various ways before they can be used. The children identify the many different uses of fossil fuels and learn that crude oil, particularly, is used in the making of a great many products including paints, building materials, and plastics. They also learn that all three fossil fuels are used to generate electricity in power plants.

Since the earth's supply of fossil fuels is limited, the children learn that we should try to conserve energy from fossil fuels. Level 3 proposes three different ways of doing this. We should be wise and careful in our use of machines and appliances that get their energy from fossil fuels. We should consider no longer using fossil-fueled machines and appliances that we don't really need. Whenever possible, we should use alternative sources of energy, especially food energy (personal energy).

A related emphasis in the latter part of Level 3 is the wise use of *products* derived from fossil fuels. Avoiding unnecessary waste in this area not only helps to conserve fossil fuels, but also protects the environment (since less garbage is produced).

Level 4

After a brief recapitulation of key ideas presented in earlier levels, Level 4 of the SEEDS program further develops the concept of how we must extract energy sources in order to use them. The children classify various energy sources as renewable or nonrenewable. They examine the flow of energy through food chains—long and short—and investigate the effects of altering the balance of nature.

In the course of their inquiry into solar energy, the children contrast the use of solar heat with the use of heat from a fossil fuel to cook food. They note advantages and disadvantages of the two methods. Through the construction of a solar heater, the children explore the use of the sun's energy to heat air.

Continuing their investigation of renewable energy sources, the children next demonstrate the water cycle and identify important uses of water energy. They also do a demonstration to show what causes wind. Various uses of wind energy are discussed.

Wood is another important renewable source of energy, as well as being the raw material for many useful products such as furniture, lumber for building, pencils, paper, cork, turpentine, and cellulose. During their study of wood, the children note the importance of the sun in the growth of trees and thus in the actual formation of wood.

After exploring some of the advantages and disadvantages of using renewable energy sources, Level 4 moves on to a consideration of three nonrenewable fuels, oil, natural gas, and coal. Extraction methods for oil are examined. The children then investigate the structure and function of pipelines and think about some of the environmental effects of pipeline leaks and oil spills. They also study extraction methods for coal, their effects

on the environment, and the various ways in which land is reclaimed after mining operations have been completed. Good and bad effects of fossil fuel extraction are summarized and evaluated within the context of a simulated "town council meeting."

Level 4 ends with a consideration of ways in which we can use energy wisely.

Level 5

After a brief recapitulation of key concepts presented in preceding levels of the SEEDS program, Level 5 points out that energy may manifest itself in the form of heat, light, sound, or motion. The children are then guided into a further investigation of energy as motion. They learn that energy of motion, or kinetic energy, can be transferred from one object to another. The amount of kinetic energy depends upon the speed and mass of an object. Energy can also be stored and then released later. The students are introduced to the concept of the force of gravity. They deduce how the position and mass of an object are related to its potential, or stored energy.

Next, the children demonstrate how the energy of wind, moving water, and steam can be converted by means of windmills, waterwheels, and turbines. They investigate the methods of generating and measuring electricity. They also classify some forms of energy produced by electrical appliances—mechanical energy, heat energy, light energy.

The children's concept of energy flow through food chains is expanded, and they learn to use the terms *producer*, *consumer*, and *decomposer* in this context. They investigate ways in which energy is lost along food chains, and enlarge their concept of the balance of nature and the interrelationship of all living things.

During their consideration of fossil fuels, the children explore the effects of the conversion of these fuels to electricity. They identify ways in which people use electricity at home and at school, and learn to calculate the amount of electricity used in kilowatt hours. They also study the overall use and importance of petroleum and petroleum products in our society. The refining of petroleum and its effects on the environment are an important part of this study.

Finally, the children are led to think about ways of using energy more wisely. Among these ways are the utilization of short as opposed to long energy chains and the development of practical uses of sulfur, fly ash, propane, and other by-products of energy conversion processes. Simulated case studies give the children opportunities to evaluate pros and cons, and make some energy-related decisions of their own.

Level 6

After a brief review of key concepts developed to this point in the SEEDS program, Level 6 leads the children into a consideration of energy use in the processing, preserving, and packaging of foods. These activities not only use a great deal of energy, but also have serious environmental effects. In particular, throwaway containers are investigated.

The children study methods of garbage disposal. They suggest alternatives to intensive packaging, and ways of reusing waste products. They distinguish between *reusing* (using an object again in the same form for a different purpose) and *recycling* (changing an object's form so it can be made into a new and different product). They discuss ways of avoiding waste.

Level 6 then moves on to an investigation of the automobile as one of the leading energy-consumers in our society. A great deal of energy is used in the manufacture of automobiles. Automobiles require a large amount of energy from fossil fuels in order to run. The children identify and evaluate the effects of automobile use, both on the environment and on society in general.

They think about ways of recycling material from old automobiles. They also learn to calculate the fuel efficiency of automobiles, and suggest possible reasons for greater or less efficiency in particular cases. In conclusion, the children are encouraged to distinguish between needs and wants, with a view to eliminating or reducing the use of energy-consumers that are luxuries rather than necessities.

Additional Investigations

The Additional Investigations are short, hands-on activities that have been prepared to enhance the acquisition of science process skills. They are especially suitable for use when SEEDS is taught as part of a core science curriculum. Each investigation is correlated to one or more activities in the core materials. The following tables of contents indicate the topics investigated.

Additional Investigations 4

1 How Much Energy Can We Save?
2 What Will Happen to a Pond-water Ecosystem that Has No Light?
3 How Much Warmer Does a House Facing South Get than a House Facing North?
4 Which Stores Solar Energy the Best—Sand, Water, or Paper?
5 How Much Pure Water Can Be Obtained from 1 L of Muddy Water, Using a Solar Still?
6 How Much Faster Does a Sample of Warm Oil Flow than a Sample of Cold Oil?
7 What Are the Properties of Coal?

Additional Investigations 5

1 How Many Candles are Needed to Boil 10 mL of Water?
2 What is the Best Lightbulb You Can Make?
3 What Conditions are Best for Growing Bread Mold?
4 What Kinds of Particles Are in the Air Outside?
5 How Fast Can Water Be Heated with a Piece of Wire and a Generator?
6 How Much Faster Does Alcohol Evaporate than Water?
7 Will a Four-blade Propeller Lift Twice as Many Washers as a Two-blade Propeller?

Additional Investigations 6

1 How Much Energy Does a Peanut Have?
2 Can We Save Energy by Sun-drying Grapes?
3 What Do You Get When You Burn Garbage?
4 Why Does a Tin Can Rust?
5 How Does Nature Recycle Organic Waste?
6 What's Happening to a Fallen Tree?
7 How Far Will an Elastic Band Stretch Before It Moves Different Masses?
8 Do Some Cars Pollute More than Others?
9 Will Water Boil Faster in a Covered or an Uncovered Pot?
10 How Can You Cook a Hot Dog Using Solar Energy?

Core Objectives and Skills

Method of Listing Objectives in SEEDS 1—6

The pedagogical goal of the SEEDS program is not only to foster the development of understanding and thinking processes with regard to energy and the environment but also to promote attitudinal learnings that will manifest themselves in positive actions, feelings, and values. Both kinds of objectives—cognitive and attitudinal—are included among those listed at the beginning of each activity in the Teacher's Guide.

The objectives are listed in as specific a manner as possible, using concrete verbs such as *demonstrate, compare, contrast, classify, explain, recognize, investigate,* and *examine.* There are several reasons for listing the pedagogical objectives so specifically at the beginning of each activity:

1. A clear statement of objectives can help the teacher to assess whatever skills and knowledge the children may already have.

2. Some of the objectives listings may actually be presented to the children themselves rather than serving as teacher information only, especially at levels 4—6. Understanding the objectives of a particular activity can help the children to focus upon the desired outcomes of the activity.

3. The listing of educational objectives can help teachers to plan additional learning experiences in conjunction with particular activities, if they wish to do so.

4. The objectives listings are an important aid in evaluation of the children's learning. This point will be discussed in greater detail later.

The following pages show the core objectives charted by organizing concept.

Energy Literacy Objectives | Levels 1, 2, and 3

ORGANIZING CONCEPTS	SPECIFIC CONCEPTS		
	LEVEL 1	LEVEL 2	LEVEL 3
The Nature of Living and Nonliving Things	5. Distinction between living and nonliving things. 6. Some characteristics of living and nonliving things. 14. Main parts of a plant.	16. Main parts of a tree.	
The Nature of Energy	2. Energy seen as motion. 15. The sun's energy—seen as light. 17. The sun's energy—felt as heat.	1. The term *energy*.	1. The term *energy*.
Uses of Energy	1. Food energy allowing humans to walk, run, and play. 3. Use of energy by people—to move. 4. Use of energy by other living things—to move. 7. Use of energy by machines — to move, to produce heat, and to produce light.	2. Some common sources and uses of energy. 8. Examples of wind-energy use. 12. Examples of use of energy from moving water. 18. Examples of use of energy from burning wood.	2. Some common sources and uses of energy. 12. Some uses and products of fossil fuels.

	LEVEL 1	LEVEL 2	LEVEL 3
Sources of Energy—Renewable and Nonrenewable	8. Energy for people from eating food. 9. Energy for other living things—from food. 10. Energy for machines—from gasoline or from electricity. 11. Plants' need of sunlight, soil, water, and air in order to live and to grow. 12. Energy for people—from eating plants. 13. Energy for other living things—from eating plants. 21. Energy for people—from eating animals and animal products. 22. Energy for other living things—from eating animals.	2. Some common sources and uses of energy. 5. Some renewable energy sources. 7. Energy in wind. 11. Energy in moving water. 17. Trees as a source of energy.	2. Some common sources and uses of energy. 5. Fossil fuels as most commonly used source of energy today. 6. Fossil fuels as energy from the sun, stored in the bodies of plants and tiny animals that died millions of years ago. 9. Three forms of fossil fuels: solid (coal and oil sand), liquid (crude oil), and gas (natural gas). 14. Distinction between renewable energy sources (such as wind, water, and wood) and nonrenewable energy sources (such as coal, oil, and natural gas).
The Importance of Energy from the Sun	16. Plants' need of the sun's energy to produce food. 18. The sun's heat as the moving force in the production of water and plants' need of water to produce food. 24. Living things' need of the sun's energy to live and to grow.	3. The sun as the most important source of natural energy. 6. The sun's role in the production of wind. 10. The sun's role in the production of water. 15. The sun's role in the production of wood.	3. The sun as the most important source of natural energy.

	LEVEL 1	LEVEL 2	LEVEL 3
The Interrelationship of all Living Things with Each Other and with their Environment	19. Interaction of plants and animals with their surroundings. 20. Interaction of people with their surroundings. 23. A "food chain" as showing energy flowing from one living thing to another.	4. Distinction between a natural environment and an environment made by people.	19. The use of fossil fuels and their products as affecting the environment in serious ways.
Wise Use of Energy and Natural Resources	25. Wise use of food. 26. The basic concept of conservation—saving through wise use. 27. Wise use of energy from electricity. 28. Wise use of energy from oil and gasoline.	9. Wise use of wind energy. 13. Wise use of electrical energy from moving water. 14. The basic concept of conservation—saving through wise use. 19. Limited supply of energy from wood. 20. Wise use of energy from wood. 21. Use of both energy and trees in making paper. 22. Recycling of paper.	4. The basic concept of conservation—saving through wise use. 15. Limited supply of fossil fuels. 16. Examples of use of fossil fuels. 17. Distinction between needs and wants. 18. Ways of saving fossil fuels by using only those machines, appliances, and products that are really needed. 20. Ways of using alternative sources of energy, especially energy from food.
Extraction, Conversion, and Distribution of Fossil Fuels			7. Extraction of fossil fuels. 8. Processes for extracting coal. 10. Processes for extracting crude oil and natural gas. 11. Preparation and conversion of fossil fuels. 13. Beneficial and harmful effects of fossil fuel extraction.

Energy Literacy Objectives Levels 4, 5, and 6

ORGANIZING CONCEPTS	SPECIFIC CONCEPTS		
	LEVEL 4	LEVEL 5	LEVEL 6
Sources of Energy—Renewable and Nonrenewable	1. People's need for energy sources. 3. Coal, oil, and natural gas as fossil fuels. 5. Energy sources as renewable or nonrenewable. 12. The renewable qualities of solar energy. 13. The water cycle. 16. The wind cycle. 20. Comparison of qualities of wood to the qualities of fossil fuels. 22. Distinction between two kinds of oil deposit—surface and underground.	1. People's need for energy sources. 3. Coal, oil, and natural gas as fossil fuels.	1. People's need for energy sources. 3. Coal, oil, and natural gas as fossil fuels.
The Importance of Energy from the Sun	2. The sun's role in the formation of energy sources. 11. The sun as a source of energy for heating. 14. The role of the sun in creating water. 17. The role of the sun in creating wind. 19. The role of the sun in the growth of trees.	2. The sun's role in the formation of energy sources.	2. The sun's role in the formation of energy sources.

	LEVEL 4	LEVEL 5	LEVEL 6
Uses of Energy	6. Ways in which various energy sources are used during daily activities. 7. Daily energy uses dependent on renewable and nonrenewable sources of energy.	24. Electrical appliances as consumers of energy. 25. The major consumers of electricity in the home. 26. Amounts of energy used by these consumers in kilowatt hours. 27. The major consumers of electricity in the school. 34. Our dependence on fossil fuels to maintain our lifestyle. 35. Our current rate of petroleum consumption.	38. Use of the automobile as determined by our current lifestyle. 39. The relative proportion of family driving devoted to shopping, pleasure, and work. 40. The amount of fuel required for normal automobile use.
The Interrelationship of all Living Things with Each Other and with their Environment	8. The interdependence of elements within the natural environment. 9. Comparison of food chains according to amount of energy used. 10. Ways in which the flow of energy between producers and consumers can be affected, altering the balance of nature.	18. The basic elements of a food chain. 19. The flow of energy through producers, consumers, and decomposers in a food chain. 20. The term "balance of nature". 21. Some elements of one type of ecosystem—how they affect one another in maintaining the "balance of nature".	
Wise Use of Energy and Natural Resources	4. Comparison and contrast of the relative advantages and disadvantages of using sunlight as an energy source with the use of fossil fuels as an energy source. 33. Ways in which individuals waste energy. 34. Wise use of energy. 35. Ways in which individuals can use energy wisely.	36. Wise use of energy derived from oil and other fossil fuels. 37. Long and short conversion chains. 38. Long and short conversion chains in terms of their energy use and effect on the environment. 39. Shorter chains as using less energy and producing less waste than long chains.	15. Alternatives to modern packaging techniques. 16. Ways in which waste products can be reused. 17. Reuse of waste products to help reduce the demand for energy. 18. Differentiation between the concepts *recycle* and *reuse*. 19. Recycling of "waste products" in nature.

		44. Choice of an appropriate course of action according to the analysis of a given situation. 45. Extension of energy conversion chains by using energy to manufacture consumer goods and process foods.	20. Recycling of waste products to help reduce the demand for energy. 21. Ways in which waste products can be recycled. 22. The actions necessary to conserve energy. 23. Projects that illustrate alternatives for energy use. 24. Energy-conservation practices. 34. Possible ways to decrease air pollution caused by automobiles. 36. Possible ways of recycling scrapped automobiles. 41. Distinction between "needs" and "wants". 43. Ways in which energy is wasted when it could be conserved.
The Nature of Energy		4. Use of energy when change occurs, or when heat, light, or motion is observed. 5. Heat, light, sound, motion, and electricity as forms of energy. 6. Heat, light, sound, and motion as forms of energy. 7. Kinetic energy as transferred from one object to another. 8. Kinetic energy as dependent on the speed and mass of an object. 9. Storage and retrieval of energy to perform work. 10. Use of gravity to do work. 11. Relationship of height and mass.	

	LEVEL 4	LEVEL 5	LEVEL 6
Extraction and Distribution of Fossil Fuels	23. Extraction methods for each type of oil deposit. 24. A model pipeline. 25. Problems in pipeline construction. 26. Distinction between two kinds of coal deposits—surface and underground. 27. Extraction methods for each type of coal deposit. 30. The different points of view that people in a community have with regard to extraction and development of energy sources. 31. Merit of all points of view. 32. Decision to develop or not develop an energy source in a town setting.		
Environmental Effects of Extraction and Development of Energy Sources	21. Specific environmental changes caused by developing renewable sources of energy. 28. The environmental impact of surface coal mining. 29. The effects of surface coal mining on the "web of life".		
Energy Conversion	15. The means of harnessing the energy of water. 18. The means of harnessing the energy of wind.	12. A model turbine wheel. 13. Water converted to steam doing work. 14. Form of energy produced by electrical appliances.	

		15. Electrical energy converted to heat, light, and mechanical energy. 16. The steps required to produce electricity from coal. 17. Dissipation of heat into the environment in the conversion process. 28. The steps required to produce gasoline from petroleum. 29. The main products of petroleum refining. 40. By-products from energy conversion processes. 41. Uses for these by-products. 42. Uses for other by-products.	
Environmental Effects of Conversion and Use of Energy and Energy Sources		22. Major by-products of the fossil-fuel-to-electricity energy-conversion process. 23. The effects of these by-products on the environment. 30. The environmentally harmful by-products of petroleum refining. 31. Prevention of this pollution. 32. The burning of oil products as a major cause of pollution. 43. Possible effects on the environment of some processes used to convert energy form renewable and nonrenewable sources.	

	LEVEL 4	LEVEL 5	LEVEL 6
Consumption of Energy and Energy Sources in the Manufacture, Packaging, and Use of Consumer Goods		33. Petroleum-based products.	4. Expenditure of energy in the manufacture and use of consumer goods. 5. Food processing and packaging as energy consumers. 6. Processing and packaging of foods necessary for their preservation. 7. The energy-consuming steps in processing a breakfast cereal and producing a cereal package. 9. The energy-consuming steps in the manufacture, use, and disposal of nonreturnable containers. 13. The sources of energy used in various packaging techniques. 14. Packaging techniques as determined by our current lifestyle. 25. The history of the automobile. 27. The energy-consuming steps in the life of an automobile. 28. An Auto Log. 29. Some petroleum products used in the maintenance of automobiles. 30. Some materials used in the manufacture of automobiles. 31. Comparison and contrast of the relative energy-intensiveness of different vehicles.

Environmental Effects of Producing, Using, and Disposing of Consumer Goods			8. The effect on the environment of the use of nonreturnable containers. 10. The amount of waste generated from the packaging of consumer goods. 11. The main methods of solid-waste disposal. 12. The effect on the environment of the disposal of solid waste. 26. Some of the effects on the environment of the use of the automobile. 32. The pollutants emitted by automobiles. 33. The effects on air quality caused by our use of automobiles. 35. The solid-waste disposal problem created by scrapped automobiles. 37. The effects on the environment of the use of the automobile.

The Cognitive Objectives

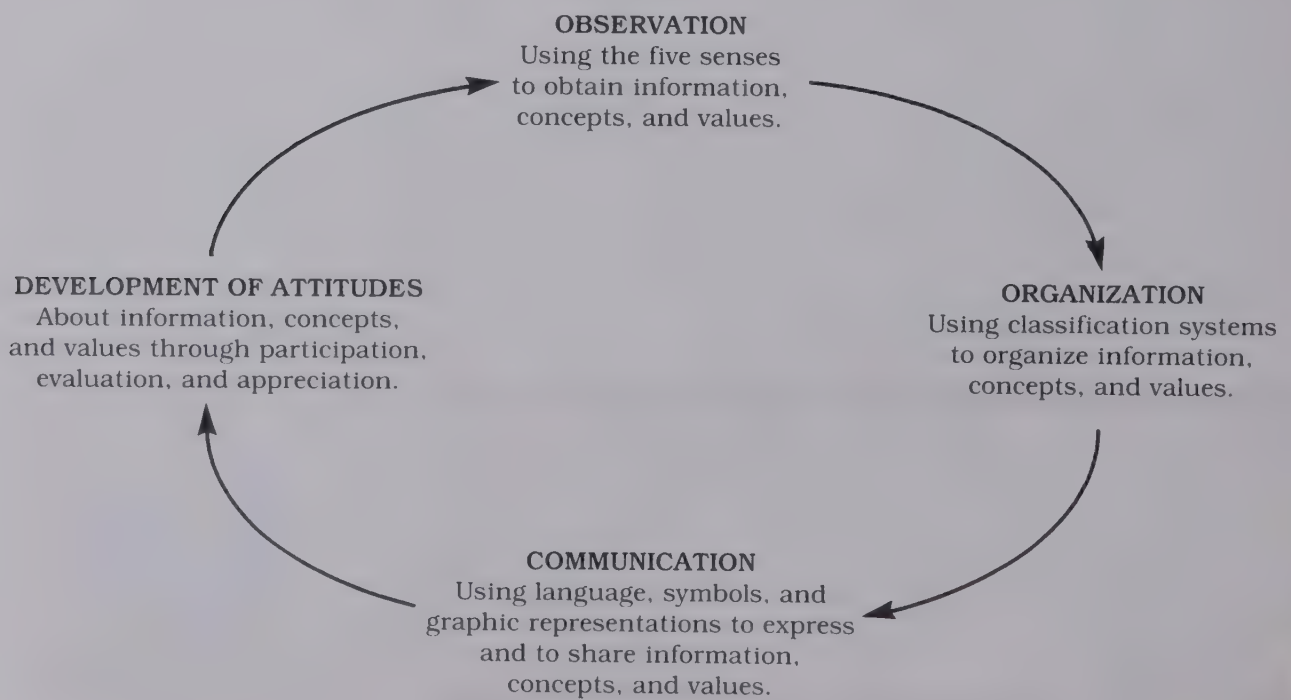
The developers of the SEEDS program have planned the series to assist children in applying rational and scientific thinking processes to energy facts and issues as we know them today. However, it is also hoped that the concepts and thinking skills gained through the series may serve as a springboard for the students in acquiring new energy knowledge and in attacking new energy problems in the future. In our rapidly changing world, children must learn *how to learn.* In order to be effective, well-adjusted members of society, they will need to become lifelong learners.

The following is a partial listing of important thinking and learning skills developed in levels 1—6 of the SEEDS program.

- Observing data carefully and accurately.
- Understanding cause and effect relationships.
- Seeing similarities and differences.
- Following order of events; understanding processes.
- Measuring.
- Collecting and organizing information with a specific purpose in mind.
- Making inferences.
- Drawing conclusions.
- Predicting outcomes.
- Evaluating information, ideas, and opinions.
- Finding evidence or proof.
- Reorganizing information into new configurations.
- Presenting information and ideas in clear accurate language, both spoken and written.
- Presenting information in pictorial or graphic form.

Some of the cognitive skills developed in levels 1—6 are reflected in the objectives listings found at the beginning of each activity in the Teacher's Guide. Others, though not specifically listed, can be drawn from the activities themselves to suit individual classes. In levels 1—3 there is an emphasis on direct perception of data through observing, listening, and doing. The broader-category skills such as classifying quantities of data, making inferences, and reorganizing information receive a greater emphasis in levels 4—6.

As the following chart shows, the main learning, thinking, and valuing skills form a circle, each leading to the next. The skills charts on the following pages are organized under these main skills. Specific process skills are charted separately.


OBSERVATION
Using the five senses to obtain information, concepts, and values.
ORGANIZATION
Using classification systems to organize information, concepts, and values.
COMMUNICATION
Using language, symbols, and graphic representations to express and to share information, concepts, and values.
DEVELOPMENT OF ATTITUDES
About information, concepts, and values through participation, evaluation, and appreciation.

Learning, Thinking, and Valuing Skills Levels 1, 2, and 3

C indicates Core Activity
X indicates Extension Activity
N indicates Enrichment Activity

GENERAL CATEGORIES	SPECIFIC SKILLS	LEVEL 1	LEVEL 2	LEVEL 3
OBSERVATION: using the five senses to obtain information, concepts, and values	By listening to a story	C1 C3 C7 C16 C17	C2 C4 C11	C3 C5
	By viewing an audio-visual presentation	C6 C14 C20	C1 C3 C5 C7 C11 C15	C1 C7 C8 C10 C11 C15
	By viewing pictures	C1 C3 C4 C7 C8 C15 C16 C17 C18	C2 C3 C4 C5 C6 C7 C8 C9 C10 C11 C13 C14	C1 C3 C4 C5 C6 C7 C8 C11 C12 C13 C14 C15
	By participating in physical activity (role-playing, manipulating objects . . .)	C1 C2 C11 C12 C19	C4 X4 C5 X6 C9 C10 X11	N2 C3 C5 C8 C9 C10 X10 X12 C13
	By observing data carefully and accurately (in naturally occurring situations, classroom demonstrations, experiments . . .)	C4 X1 X3 X4 C7 C8 C9 C10 C11 C12 C13	C4 X4 C6 X8 C10	X2 C5 X5 C6 X7 C10 X10
	By recalling relevant personal experiences and observations	C5 C6 C7 C8 C16	C3 C4 C7 C9	C7 X7 C8 C10
	By reading simple written language	(optional for Level 1)	C2 C3 C5 C6 C7 C8 C9 C10 C11 C12 C13	C2 C3 C4 C5 C6 C7 C8 C9 C10 C12 C13 C14 C15
	By doing research		X10	X6 X7 X14

		LEVEL 1	LEVEL 2	LEVEL 3
ORGANIZATION: using classification systems to organize information, concepts, and values	By recognizing similarities and differences	C1 C4 C5 C9 C11 C12 C13	C2 X2 C5	C5 C10
	By recognizing cause-and-effect relationships	C1 C3 C5 C9 C10 C11 C15	C4 C6 C7 C9 C11 C13	C3 C6 C8 C10 C12
	By following a sequence of events: by recognizing processes	C2 C11 C14 C15 C19	C3 C4 C5 C6 C7 C9 C12 C13	C3 C4 X5 C7 C8 C12 C13
	By drawing conclusions	C1 C5 C10 C11	C2 C3 C4 C6 C10 C11 C13 C14	C1 C6 C8 C9 C10 X10 C13 C14
	By predicting outcomes	C5 C9 C15	X4 C6 C10	C8 C10 X10 C13
	By giving reasons	C9 C10 C12 C13 C16 C17	C7 C9 C10	C2 C5 X12 C13
	By developing key concepts and appropriate corresponding vocabulary	C1 C2 C3 C4 C8 C12 C15 C17	C1 C2 C3 C4 C5 C6 C7 C8 C9 C10 C12 C13	C1 C2 C3 C4 C6 C7 C8 C9 C10 C13
	By collecting and / or classifying pictures under main headings or in categories	X1 N2 C5 C6 C13 C14 C18 C19	N1 C7 C13	N1
	By classifying objects or pictures to show similarities and differences	C2 C3 C4 C12 C14 C15	C2 X2 C3 C9	C3 C14
	By recognizing symbolic representations and models	C8 C9 C19	C4 C6 X6 C11	C5 C6 C8 C10 X10

	By comparing data	C1 C2 C3 C6 X9 C10 C11	X8	C5 C10 X10
	By counting number of occurrences			C10 C11
COMMUNICATION: using language, symbols, and graphic representations to express and share information, concepts, and values with others	By using oral language in informal discussion	All C Activities; most N and X Activities	All C Activities; most N and X Activities	All C Activities; most N and X Activities
	By using simple written symbols (circles, X's, lines, initial letters . . .)	C2 C3 C4 C6 C8 C9 C11 C12 C14 C15 C18	C2 C3 C7 C8 C11 C13 C14	C6 C8 C11 C13
	By preparing illustrations that demonstrate understanding	N5	N10 N12	N14
	By using simple written language		C4 C6 X8 C9 N11 C13 C14	C1 C2 C3 C4 C5 C6 C7 C8 C9 C10 C12 X12 C13 N14 C15
	By preparing charts and diagrams		X10	C5 X6 C10 C11 X14
	By constructing representational (concrete) models			X4 X6 X14
DEVELOPMENT OF ATTITUDES: about information, concepts, and values through participation, evaluation, and appreciation	By proposing appropriate actions and solutions (social and values issues)	X7 C16 C18	C10 C11	C10 C11 C13 C14 X14
	By creating a plan of action	X7 C16	C5	C11 C14
	By applying a chosen plan of action	X7	C5	C14
	By evaluating actions and solutions (social and values issues)	X7 C16	C11	C9 C13 C14 N14
	By judging worth of consequences	C17	C8 C11	C9 C13

	LEVEL 1	LEVEL 2	LEVEL 3
By formulating alternative proposals (social and values issues)	X7	C11	C13 C14
By participating in group activities (projects, games, singing)	X7 N8 C9 C12 C14 C19	C7 N11 C12 C14	C9 C10 X10 C11 C13 X14
By recognizing personal responsibility	C17 C18	C8 C11 C12 C14	C10 C11 C13 C14 C15
By appreciating and responding to artistic expression of ideas in poems, songs, stories . . .	N5 N8 N11 N14	N3 N6 N11	N4

Learning, Thinking, and Valuing Skills Levels 4, 5, and 6

C indicates Core Activity
X indicates Extension Activity
N indicates Enrichment Activity

GENERAL CATEGORIES	SPECIFIC SKILLS	LEVEL 4	LEVEL 5	LEVEL 6
OBSERVATION: using the five senses to obtain information, concepts, and values	By viewing an audio-visual presentation	C1 C2 C6 C8 C9 C12 C14 C18	C1 C4 C5 C12 C14 C18	C1 C7 C11 C19
	By viewing pictorial representations	Most C Activities	Most C Activities	Most C Activities
	By participating in physical activity (roleplaying, manipulating objects, doing experiments . . .)	C3 C6 C7 C8 C9 X10 C13 X14 C16 X16 X17	C2 C3 C4 X5 C7 C10 X10 X15 C17	X5 X6 C9 X9 X10 C11
	By observing data carefully and accurately (in naturally occurring situations, classroom demonstrations, experiments . . .)	C3 C7 C8 C9 X10 C13 X15	C2 C3 C4 X6 C8 X10 X11 C14	X2 X4 X5 X6 X8 X9 X10 X12 X14
	By recalling relevant personal experiences and observations	C4 C7 C8 C10	C1 C2 C5 C6 C8	C2 C4 C6 C8 C10 C13 C17
	By reading written language	All C Activities: some X and N Activities	All C Activities: some X and N Activities	All C Activities: some X and N Activities
	By doing research	X5 X11 X14 X17	X3 X7 N7 C10 X11	C12 X12 X14 X15

		LEVEL 4	LEVEL 5	LEVEL 6
ORGANIZATION: using classification systems to organize information, concepts, values	By recognizing similarities and differences: by making comparisons	C3 C4 C5 C7 X10 C14	C2 C5 C6 C7 C15 C18	C3 C4 C5 C7 C8 C9 C13 C17 C18
	By recognizing cause-and-effect relationships	C1 C5 C6 C8 C9 C13 C18	C1 C2 C3 C4 C5 C6 C7 C8 C18	C6 C9 C17 C18 X18
	By following sequence of events: by recognizing processes	C1 C5 C6 C8 C9 C13 C14 C18	C2 C3 C4 C5 C6 C8 C11 C12 C15 C16 C18	C2 C3 C4 C6 C9 C12 C13 C18
	By giving reasons	C1 C3 C9 C14 C17	C1 C2 X5 C6 C7	C1 C2 C10 C11 C16
	By classifying objects, pictorial representations, etc. under main headings or in categories	N2 C6 C17	C5 C13 X13	C2 C4 C5 C11 C13 C17 C18 X18
	By classifying objects, pictorial representations, etc. to show similarities and differences	C3 C4 C5 C6 C7	C8	
	By recognizing symbolic representations and models	C6 C8 C9 C13	C4 C5 C7 C14	X6
	By recognizing main ideas	C1 C2 C6 C9 C10 C14 C15 C17 C18	C1 C2 C3 C7 C18	C1 C6 C7 C12 C16 C19
	By drawing conclusions	C1 C7 C9 C13	C3	C7 C10
	By developing key concepts and appropriate corresponding vocabulary	C1 C2 C5 C6 C7 C8 C10 C11 C12 C13 C14 C15	Most C Activities	Most C Activities

By recognizing relationships (numerical, simple ratio and proportion)	C5	N7 X7 C14	C17
By measuring	C3 C7	C14	X14
By making calculations		C9 X9 C10 X10	C17
By drawing on previous personal experiences and observations in order to make inferences	C1 C4 C5 C6 C7 C10 C14	C1 C5 C6 C15	
By speculating about or inferring probable reasons	C9 C13	X10	C7 C9 C17
By speculating about or inferring probable cause / effect relationships	C9 C10 C11 C15	C8 C12	C6 C14 C16
By speculating or making inferences about sequences of events; processes	C5	C5 C6	C6 C15
By making inferences based on and including (hypothetical) situations	C5 C17	C6 C13	C1 C6 X14 C16 X16
By speculating about meanings of unfamiliar words	C13	C6 C8 C11	
By predicting probable sequence of events	C5		
By predicting probable outcomes, effects, and / or results	C3 C4 C6 C13 C15 C17	C2 X5 C6 C7 C14	X6 C16
By proposing appropriate actions based on prediction of outcome	C17	C14 N14	C10
By predicting possible future developments (in society . . .)	C9 C10	C14 N14	C1 C10 C16

		LEVEL 4	LEVEL 5	LEVEL 6
COMMUNICATION: using language, symbols, graphic representations to express and share information, concepts, and values with others	By using oral language in informal discussion	All C Activities; many X and N Activities	All C Activities; many X and N Activities	All C Activities; many X and N Activities
	By using oral language in formal interviews, meetings, speeches	X4 C16 X16 X17	C17	X5 X6 X10
	By preparing pictorial representations that demonstrate understanding	C13	N2 X3 N6	X12 C15
	By completing and / or making charts and diagrams	C3 C4 X4 C5 C6 C7 C8 X9 X10 C11	X3 X6 C8 C10 C14 C16	C2 X2 C3 C5 X6 C7 C8 C11 C12 X12 X14 C16 C17
	By indicating features on a map	X2 X10	X5	
	By using symbolic representations	X2		
	By constructing representational models	C13	C4	X6
	By using written language	Most C Activities; many X and N Activities	Most C Activities; many X and N Activities	Most C Activities; many X and N Activities
	By preparing oral and / or written summaries, reports, paragraphs . . .	C3 C13 X14 C16 C17	X3 N13 N14	C4 X5 C11 X12 X14 X16
	By writing letters			X3 X5

DEVELOPMENT OF ATTITUDES: about information, concepts and values through evaluation, participation, and appreciation	By proposing appropriate actions and solutions (social and values issues)	X5 C7 C13 C17	X10 C13 C14 N14 C15	C5 C6 X8 C11 C14 C15
	By evaluating actions and solutions (social and values issues)	C9 C11 C13 C15 C16 C17	X10 C15 C17 X17	C6 C7 C10 C14 C18 X18
	By judging worth of consequences	C7 C11 C13 C16 C17	X10 C15 C17 X17	C6 C7 C10 C11 C18
	By creating a plan of action	C17	X10	
	By applying a plan of action		X10	X3 C11
	By participating in group activities (projects, experiments, meetings, games . . .)	C3 C6 C7 C8 N10 C13 C16	C2 C3 C4 C7 X10 C17	X8 C9 C11 C15
	By recognizing personal responsibility	X5 C7 C17	X10 C13 X13 C14 N14 C15	C1 X8 X9 C11 C18 X18
	By appreciating and responding to artistic expression of ideas in poems, songs . . .	N2 N10		

SPECIFIC PROCESS SKILLS
Additional Investigations Levels 4, 5, and 6

PROCESS SKILL	LEVEL 4	LEVEL 5	LEVEL 6
Observing	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7 8 9 10
Measuring	3 4 5 6	1 2 4 5 6 7	1 2 6 7 8 9 10
Classifying	4 7	8	3 6
Communicating	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 8 9
Inferring	1 2 3 4 5 6 7	1 2 3 4 5 6	1 2 4 5 6 7 8 9 10
Predicting	4 6	6 7	1 3 4 5 6
Identifying and Controlling Variables	1 2 3 4 5 6	1 2 3 4 5 6 7	1 2 3 4 7 8 9 10
Collecting and Interpreting Data	1 2 3 7	5	3 5
Defining operationally	2 7		7
Formulating Hypotheses		2 3	4 8 9 10

The Attitudinal Objectives

An attitude may be defined as a predisposition to act in a certain way with regard to objects, persons, and ideas. Attitudes are, of course, related to knowledge. However, they also have a connection with emotions and feelings. The goal of the education system is not to induce all children to adopt exactly the same set of attitudes and values. Rather, it is to help children understand the sources of their values and attitudes, to alert them and to encourage them to act and behave in accordance with their chosen attitudes and values.

With specific reference to energy and environmental education, the SEEDS program attempts to cultivate the following positive attitudes and values.

- Being concerned for other people for the common good.
- Recognizing one's personal responsibility to the society in which one lives.
- Recognizing one's responsibility for one's environment, and attempting to live in harmony with that environment.
- Conserving energy, natural resources, and manufactured products; avoiding waste of any kind as a matter of principle.
- Recognizing the complexity of energy issues and maintaining an open mind with regard to differing viewpoints and new information that one may encounter in the future.

An attitudinal objective in the SEEDS program is usually linked with an opportunity for the children to exhibit behaviors and / or carry out practical actions arising naturally from that objective. For example, in Activity 7 of Level 1, the children consider ways of helping other people. The teacher then guides them in actually carrying out their plans for helping specific real individuals in their families or community. In Activity 9 of Level 6, the children discuss how waste can be reduced through recycling. They then actually go through the process of recycling waste paper in order to make new sheets of usable paper.

Integrating SEEDS with the Elementary Curriculum

Relationship of SEEDS to Science, Social Studies, and other Subject Areas

By their very nature, the topics of energy and the environment relate to almost everything we do. Thus, in one sense, the teaching of energy literacy and environmental studies should be thought of as an integral part of the curriculum—to be drawn in whenever appropriate no matter what subject area is officially being considered.

However, in practical terms, following this approach exclusively often results in a somewhat fragmented treatment characterized by serious omissions and undesirable overlaps from one level to another. The SEEDS program, with its comprehensive scope and carefully planned progression of learning experiences, provides a solid foundation and focus for effective energy and environment education as part of a science or social studies curriculum or on its own as an independent energy curriculum.

The SEEDS program is essentially an interdisciplinary one. The most prominent subject areas identified within it are science and social studies. The scientific and social aspects of energy and environment issues are closely linked. A serious consideration of these issues requires the information, skills, and attitudes taught in both disciplines.

The practise of centering learning on particular problems—drawing in data and skills from a wide range of disciplines as needed—is widely accepted in educational circles today and is particularly applicable to the elementary levels. The SEEDS program, while drawing most heavily on the subject areas of science and social studies, also brings to bear knowledge and skills from a wide range of other disciplines, including language arts, mathematics, health education, music and art. These other disciplines are integrated in various ways within the Core Activities themselves. The Extension and Enrichment Activities indicate the particular subject area. The Additional Investigations provide an opportunity for children to further apply science process skills.

Practical Suggestions on Scheduling and Timetables

Each school, and even each class within a school, is different in interests, background, and specific learning needs. It is therefore inappropriate to be prescriptive about the way in which the SEEDS program can best be incorporated into the schedule. However, the program is designed to provide approximately four to six weeks of study.

Almost any time of the school year would be appropriate for the SEEDS program. However, a time period when relatively good weather can be expected would be preferable, since many of the learning experiences relate directly to the outdoor environment. Another consideration—with regard to Level 1—would be the limited experience and reading ability of the children during the early part of the year. For these children the program might best be scheduled sometime during the second half of the year.

With regard to timetable adjustments for particular classes, the suggestions given here cannot be prescriptive since situations vary so greatly. As a rule, it is probably best to schedule a definite amount of time per day or week for the SEEDS program, while still allowing for some flexibility, if possible. If the actual amount of time remains flexible, the children will almost always have the satisfaction of completing investigations of projects without being interrupted. Sometimes a longer period can be crucial to the gaining of a particular concept or insight.

At the beginning of each activity in the SEEDS Teacher's Guide, the teacher is informed of the length of time likely to be taken not only by the basic Core Activity, but also by any Extension or Enrichment Activities that follow. Generally, the time suggested for Activities increases gradually from level to level within the series. The shorter attention span of younger children has been especially taken into account in Levels 1—3. The activities are shorter in these primary levels. There are also more frequent switches from listening to talking to demonstrating to reading to writing, and so on within an activity.

The following are some overall considerations and principles that administrators and teachers may wish to keep in mind as they plan their timetables with reference to the SEEDS series.

1. One possibility for the SEEDS program is that it be scheduled for periods usually given to science and social studies. The time of day is not crucial in many cases. However, if the children have been asked to bring something from home to show the class, it may be best to schedule the related activity for the first period of the day. Primary children, especially, may be anxious to share information about what they have brought immediately.

2. The SEEDS program, Levels 1—6, does not require much use of special rooms or special facilities within the school. Since an average classroom with the usual equipment will suffice for most of the activities, the need for complicated meshing of schedules among teachers is kept to a minimum.

3. In some cases it may be helpful to appoint a SEEDS program coordinator for the school. (Such a person could not only assist teachers in planning timetables, but could also perform such valuable services as investigating local community problems and resources with regard to energy and the environment.)

4. Team teaching of the SEEDS program or parts of it may be worth considering as a possibility. In this way teachers with special knowledge and capabilities in the area of energy and environment education could share their expertise with more than one class within the school.

Teaching Strategies Used to Present and Develop Concepts

The "Guided Discovery" Approach

Some science and social studies curricula strongly emphasize processes of inquiry such as observing, describing, measuring, classifying, inferring, and predicting. Others are based on the idea that science and social studies are essentially organized bodies of subject matter. In actual fact, both *processes* and *subject matter* are important. There is a place in the study of science and social studies for both experimentation and reading. Children cannot learn everything from experimentation and firsthand experience. On the other hand, it is important for children to practise processes of inquiry and develop the attitudes of scientifically-minded persons. Scientific processes and attitudes can be transferred to other subject areas, and are valuable as a basis for learning of any kind.

The SEEDS program uses both "telling" and discovery as strategies for the presentation and development of concepts—the "guided discovery" approach. The strategy used in a particular core depends upon such factors as the subject matter under consideration, the probably availability of suitable equipment, and the relative maturity of the children. However, there is in general a stronger emphasis on the discovery approach. It should also be noted that the "discovery approach" may take either an *inductive* or a *deductive* form.

In the inductive form or pattern of discovery, children might make certain observations, form hypotheses based on these observations, and then experiment to test the validity of their hypotheses. In the deductive form, on the other hand, the children might be presented with a generalization first (rather than with a set of observations). They would deduce certain consequences from this generalization. Then they would conduct a suitable experiment and compare its results with the consequences that they had previously deduced. Children might also suggest experiments themselves, following similar methods of investigation.

The following are some practical guidelines for the classroom implementation of the experiments, demonstrations, investigations, and other "guided discovery" experiences suggested in the SEEDS program.

1. As far as possible, allow the children to plan and organize the experiments, making their own predictions about what might happen and drawing their own conclusions about the results.

2. Keep experiments and demonstrations simple. Most of the materials suggested in the SEEDS Teacher's Guides are readily obtainable at home or at school. Teachers and / or children should have little difficulty assembling the required materials. Another advantage to the "homemade" approach is that elementary school children more readily relate to and understand experiments involving familiar, everyday objects.

3. Make sure that the children keep the purpose of an experiment firmly in mind as they are conducting it. It may sometimes be advisable to write the purpose on the board for ready reference.

4. It is often helpful to have the children keep a written record, a graph, or a chart of the experiment as it is being conducted. Small drawings of things being observed are also a good way to record information. However, the children should not *always* be required to keep a written record of their experiments, as this may dull their sense of excitement and discovery.

5. Whenever possible, allow the children to manipulate the apparatus themselves, even if they only repeat the experiment or demonstration after you have done it once.

6. Take advantage of situations in which experiments do not follow predicted paths. If this happens (for example, if a plant grows well without air even though the children have learned that plants need air), a *real* problem has arisen. It is not in any sense a "staged" problem. As a result, the children are challenged to think more deeply and plan more wisely. Thus, greater learning may actually take place.

7. Guide the children to apply information gained from experimentation to real-life situations. Your own local situation will suggest ways of doing this. Perhaps the children can help to clean up a vacant lot, thus reducing the effect of garbage on the environment.

8. In your preparation for teaching a particular SEEDS activity, you may wish to carry out a "dry run" of any experiments and demonstrations connected with the activity. In this way you can solve any unforeseen problems beforehand. This may be particularly appropriate if you are teaching at a primary level.

9. You may wish to consider the possibility of filming or video-taping some of the experiments and demonstrations. Children may be interested in making films of themselves performing experiments. Such films could be shown to other classes or to parents on a "parents' day" at school.

Questioning and Class Discussion

Skilful questioning plays an important part in the development of concepts and cognitive skills in the SEEDS program. The following are some of the characteristics of the suggested questions found within the activities in the Teacher's Guides.

1. The questions are clear and specific.

2. They are arranged in carefully planned sequences. They are not asked at random, but in integrated series in order to accomplish specific purposes. Sometimes the purpose of a question series is to refine the children's understanding of certain concepts. Sometimes the goal is to identify and / or review important facts. At other times the purpose of the questioning is to have students apply their knowledge to real or hypothetical problems.

3. There is a balance between fact-oriented questions and questions requiring thoughtful answers. Questions requiring thoughtful answers in the SEEDS program encourage the children to use a variety of cognitive processes, including:

recalling data;

classifying data;

comparing and contrasting data;

showing cause and effect relationships;

giving examples and illustrations;

making and evaluating decisions; and

analyzing or synthesizing facts.

The Story Approach in SEEDS Levels 1—3

Teaching strategies in the primary levels of the SEEDS program include all those used at the higher levels: experimentation, demonstration, questioning, class discussion, group activities, community-based activities, and written work on activity sheets. However, the primary SEEDS levels are different from the others in that they sometimes use narratives to present certain key concepts. These narratives have a number of important functions:

1. They reinforce, enlarge, and supplement the children's firsthand experiences.

2. At the primary levels, stories lay the foundation for more formal learning.

3. They provide the sense of personal involvement so important with young children.

4. They help to vary the pace. This is especially important at the primary levels, where the attention span is relatively short.

5. Stories extend the imaginative powers of children in ways that can help them cope more effectively with everyday life.

6. The SEEDS stories, particularly in Level 1, present role models whose actions the children are encouraged to imitate. (Both adult and child characters in the Level 1 stories are seen helping other people, taking care not to waste food, conserving electricity, and so on.)

7. The story format has the capacity of presenting material that children may not be able to grasp in another form such as group discussion or lecture by the teacher.

8. Stories have a unique capacity for combining the cognitive and attitudinal domains. They present basic facts. They encourage thinking skills. But at the same time they transcend both, adding the important dimensions of feeling, acting, and valuing.

9. Stories at the primary level are useful in providing a synthesis, or meaningful structure, for what might otherwise be just a collection of isolated facts.

10. In an incidental way, the stories in SEEDS contribute to the children's social development and

foster their communication, language, and listening skills.

11. The SEEDS stories are factually accurate and effective in conveying information.

In Level 1, the story "Do What I Do" introduces the idea of human energy as motion. Levels 2 and 3 use stories for such purposes as contrasting natural and artificial environments, illustrating wise and unwise use of trees as a natural resource, and explaining why coal, crude oil, and natural gas are called fossil fuels.

The stories themselves are found within the appropriate Core Activities in the Teacher's Guides. Colorful pictures in the Student Books illustrate the stories for the children. Generally, it is expected that a teacher will read a story aloud, having the children follow the corresponding series of pictures in the Student Book. However, if you have particularly able readers in your class, you may wish to have the students read parts of the stories themselves.

You also might like to put á particular story on tape. If it is a story that contains conversation, as many do, you might enlist some helpers to take the various parts, reading the dialogue aloud for the tape recording. Having the story on tape would free you as the teacher to perhaps point at the pictures in the Student Book as the narrative progresses.

Group Activities

Many of the learning experiences suggested for the SEEDS program involve the children working in groups. This is especially true of the Extension, Enrichment and Investigation activities that follow the basic Core Activities. Small-group activity may sometimes be more difficult to organize and oversee than whole-class instruction. However, group work does have certain distinct advantages:

1. Group activities give children a measure of self-determination and freedom.

2. The development of critical thinking is encouraged by group work. The group must propose various courses of action, rejecting some and choosing others.

3. Working in groups develops the children's organizational abilities.

4. The children practise communication skills, and become aware of effective group processes.

5. Group work fosters a spirit of active cooperation, in which a common goal and group welfare are both perceived as important.

6. Children gain new insights into the talents and abilities of their classmates.

7. Group work is a strategy for making learning more meaningful and immediate, since a group project usually involves the application or transfer of learning that has previously taken place.

Community-based Activities

Two obvious ways of making use of community resources are: inviting visitors from the community to give talks or demonstrations, and taking the children on field trips into the community.

Your school may already have a list of suitable resource persons with differing areas of expertise. Sometimes the children themselves may be able to suggest names of possible visitors. Keep the following suggested guidelines in mind when arranging for a visit by a resource person.

1. Find out ahead of time what specific contribution the visitor can make.

2. Discuss with the visitor your reasons for inviting him or her, the grade level of the children, and a time that would be mutually convenient. It might be wise to suggest to the visitor approximately how long you would like his or her presentation to take.

3. Make sure that the children have the purpose of the visit clearly in mind ahead of time.

4. Make plans with the children regarding how they can get the most out of the visit. It is often helpful to discuss what kinds of questions they might want to ask.

5. After the visit, discuss with the children what they gained from it. Clear up any misconceptions that they may have.

6. Arrange with the children how they may thank the visitor. An individual or group might be appointed to write a short thank-you note. The class might send the visitor drawings or posters made as a result of the visit. If appropriate, you or one of the children might even telephone the visitor to thank him or her.

The following suggestions should help you to plan interesting, valuable and trouble-free field trips.

1. Have a real reason for making the trip. The

trip should be an integral part of the ongoing study, and its purpose should be clearly understood by the children.

2. Make a "dry run" of the trip yourself first in order to determine realistic objectives and identify any problems that could arise.

3. Make the necessary arrangements with: school authorities, owners or authorities in places you intend to visit, parents (secure written consent from parent or guardian for each child), and any individuals who will be helping you with transportation or supervision of the children.

4. Advise the children (and perhaps parents as well) of suitable clothing for the trip.

5. If the children are to make notes, make sure that they take writing materials with them.

6. Discuss with the class suitable conduct and standards of courtesy that should be observed during the field trip. Allow the children themselves to suggest these. You may wish to list them on the board.

7. If the group is large, you may wish to divide the children into "teams." Each team could have a captain who is in charge. The captain might be an older child, a parent, or another teacher who has agreed to help you.

8. If desired, each "team" might be given a specific assignment with regard to things to watch for or information to be gathered during the trip.

9. Don't plan for the children to see too much in one trip. Make sure that you are not rushing them through the trip. This is especially important with primary children.

10. During the field trip, encourage the children to use as many of their senses as possible. For example, they might *listen* for the call of a loon on an outdoor walk. They might *feel* the warmth of sand heated by the sun. On a tour of a bakery, they could *smell* the bread baking. They could even be allowed to *taste* the bread (providing you have arranged for this ahead of time). Of course, the sense they will probably use most is the sense of sight. Encourage them to *observe* carefully and accurately.

11. If brochures or maps or other explanatory materials are available at the place you are visiting, obtain some for later classroom use.

12. Classroom follow-up can take many forms. There should almost certainly be a classroom discussion of the experience and how well it achieved the predetermined purpose. Other possible forms of follow-up would include: oral and / or written reports, field trip booklets or diaries, posters, murals, and repeat visits to investigate aspects the children feel they did not see thoroughly enough on the first visit.

Certain cautions are in order with respect to having children make field trips into natural environments. Such environments can be much more easily damaged than we often realize, as pointed out in the following excerpt from *Nuffield Junior Science, Teacher's Guide 1*, published for the Nuffield Foundation by William Collins Sons & Co. Ltd., London, 1967, p. 268.

"Apart from the dangers created by collecting there is the possibility of damage from thirty to forty pairs of feet. This is generally less harmful to plant life than animal.

"Recently, a study was made of the effect of a group of twenty people walking through a stream with a rocky bottom. The disturbance of the stones by feet resulted in a large haul of animals, mainly stonefly and mayfly nymphs, being caught in nets placed further down the stream. Examination of these disturbed areas showed that they had a reduced population of animals compared to undisturbed area.

"Disturbance of stones in terrestrial habitats can result in the destruction of microhabitats exposing the animals to dangers of desiccation or predation. All stones turned over on the sea shore, land, ponds, or streams should be replaced as nearly as possible in their original position.

"Damage to vegetation may be slight, but for a small group of flowering plants it may mean that flowering cannot take place that season, so there will be a loss of seed this year. Clearly, if this were repeated annually some plants in the area would eventually be destroyed.

"Even slight damage to vegetation may be sufficient to indicate the presence of a nesting bird to a natural predator or suggest its presence to other humans. When we observe nesting birds we must take care not to expose the nest in any way. We must strike a balance between the need to observe and the risks of desertion and predation.

"Occasionally, the interest of the children may, as in a case we know of, when a group of ten-year-old boys wanted to band birds, have to be opposed because they would contravene the laws of the land. It is illegal to capture a bird for observation or banding unless the catcher has a licence to do so. Any such work would have to be done by a licensed specialist who could be called upon to help or take the children on a visit to a local bird observatory.

"One bird observatory run by a group of amateur

ornithologists arranges transport facilities for visiting school parties, and its members demonstrate the varying techniques used. They are most helpful to parties wishing to do general field work in the area surrounding the observatory, but do not allow visits to the rocky shore and sand dune areas during the breeding season of ground nesting birds.

The use of local experts in this way can be of great value both to the teacher and the class. Information about the distribution of rare plants and animals and the areas in which they occur is valuable in deciding suitable areas in which the pupils can work. Clearly such areas should be avoided for general field work."

Review and Evaluation

The progression and continuity of the SEEDS program follow a spiral pattern. It is often impossible to present an important concept fully when first introduced because of the relative immaturity of the children. However, in the SEEDS program, that same concept is presented again within the level, and also from level to level. Each time the concept is presented, the context is somewhat different and the meaning is more completely developed: such an approach helps the children gain an increasing understanding of a core of essential ideas. The use of the spiral approach also constitutes a built-in review mechanism within the program.

In spite of the continual recycling of concepts, you may find on occasion that certain facts and ideas need to be reviewed or retaught.

Evaluation of child learning can take several forms. Particularly applicable to the SEEDS program is the observation of child behavior with reference to specific stated objectives.

Since the learning objectives for each activity of the SEEDS program are specifically stated at the beginning of that activity in the Teacher's Guide, they provide a basis for evaluation. Other important educational goals may be found in the sections on cognitive and attitudinal objectives (pages 24 and 35 of this Professional Reference Guide). Each child should be observed over a period of time, and those observations should be recorded in writing periodically. Such accumulated written observations can serve as a valuable basis upon which to form an opinion about individual child learning.

One should be careful to keep individual differences in mind. What might represent real progress for one child might be less important for another.

Also, it is not enough to be satisfied with mere verbal performance. The emergence of new behaviors in the classroom also indicates that learning has taken place. The following are some examples of acquired behaviors:

1. Showing originality and resourcefulness in research.
2. Finding solutions through reading.
3. Participating in experimentation.
4. Engaging in investigative activities on one's own initiative.
5. Beginning to expect and look for predictability and order in relation to natural phenomena.
6. Distinguishing fact from fancy.
7. Questioning and evaluating sources of information.
8. Withholding judgment until sufficient evidence is available.
9. Demonstrating the ability to be either a leader or a follower, depending on the situation.
10. Showing by actions that one understands and sympathizes with the feelings of other people.

The review activity sheets in the SEEDS program are intended as another criterion for the evaluation of child learning. (However, they should not be used as the only criterion.) These sheets have been designed in such a way that they constitute a learning experience as well as providing a means of assessment. Questions are of several different types, concentrating not only on subject matter but also on thinking skills such as identifying reasons, understanding processes, and making comparisons. In Level 3, questions in the Student Book provide another instrument for assessing the day-to-day acquisition of learning of the children.

Materials

Materials Found Within the Program Itself

As stated earlier, the SEEDS program for Levels 1—6 provides a full range of materials for each level:

1. A comprehensive Teacher's Guide.
2. Student Book that has been designed to stimulate the children's curiosity about energy and the world around them.
3. A series of reproducible Activity Sheets for written work (found at the end of the Teacher's Guide).
4. A sound filmstrip specifically designed to reinforce the concepts and information presented in each of the Levels 1 through 6. Concept framework filmstrips are also provided: one for Levels 1—3 and one for Levels 4—6.
5. A set of Additional Investigations where appropriate.
6. A Professional Reference Guide.

Complete and specific instructions for the use of the materials will be found as one progresses through the numbered activities in the Teacher's Guide. The use of the Student Book, particularly, is quite flexible. Sometimes it is used to introduce a concept. Sometimes it is used as a focus for group work. At other times the Student Book is used to summarize or review what has gone before.

The children are not to write in their Student Books. However, the reproducible Activity Sheets for each level provide for written reinforcement of and response to what has been learned. Of course, at Level 1, the children's work on the Activity Sheets consists mostly of classifying pictures, matching, placing pictures in sequence, and coloring. As the children progress through the level, they are gradually required to use more and more written language.

At the primary levels of the SEEDS program, the use of an Activity Sheet is almost always suggested for the end of a Core Activity (rather than sometime during the course of the Core Activity). One reason for this is that the activity sheets generally provide reinforcement of what has just been learned. Another reason is that primary level children often vary greatly in rate of working and amount of individualized help required. If a teacher has finished the main part of the presentation before handing out the activity sheets, he or she is then free to work with the children on an individual basis as needed.

Specific instructions for the use of the SEEDS filmstrips are found within the numbered activities in the Teacher's Guides. Practical suggestions for the use of filmstrips in general are given in the section entitled "Choosing Supplementary Audio-visual Materials" and "Using Audio-visual Materials," on page 48 of this Professional Reference Guide.

The Additional Investigations provide for direct student involvement through observation and manipulation of materials and / or occurences. Each spins off from the concepts developed within the body of the program.

The Professional Reference Guide provides helpful teaching strategies, as well as background information about the program, and the kind of pedagogy it is based on.

Concrete Materials to Accompany the Program

A recent survey of science teachers revealed that one of the greatest problems they experienced was the difficulty of obtaining materials for scientific experiments and demonstrations. The materials required for experiments and demonstrations in the SEEDS program have been deliberately kept very simple. For the most part, they are the kinds of things that can be easily found in the average school or home. Simple "homemade" apparatus is not only easier to obtain, but also more meaningful

to elementary school children. Such materials help them to see more readily how the concepts they are learning relate to their own immediate environment.

In addition to the materials directly required for experiments and demonstrations, the teacher of the SEEDS program would be well advised to assemble as many other related "real things" as possible. These might include: classroom plants of different kinds, a rock collection, a shell collection, a leaf collection, samples of various kinds of wood, samples of fossil fuels, objects made from fossil fuels, a terrarium, an aquarium, and so on. Of course, many elementary school classrooms already have an abundance of this kind of material. However, the importance of real "touchable" things, or *realia*, cannot be emphasized too much, especially at the primary levels. Some of the many advantages of realia in the classroom are that they:

1. Introduce a variety of stimuli, encouraging the children to use all of their senses—seeing, hearing, touching, tasting, and smelling.
2. Increase and sustain the children's attention.
3. Bring into the classroom events and phenomena that would otherwise remain remote in place or time.
4. Illustrate applications of abstract concepts, and increase their meaningfulness for the children.
5. Can promote a spirit of cooperation and develop a sense of responsibility in the children, especially if their help is enlisted in assembling the real objects and caring for them.

Printed Materials as a Resource for the SEEDS Program

A wide selection of books, pamphlets, pictures, and other printed materials related to energy and the environment should be made easily available to the children if at all possible. A comprehensive collection of such material will help to meet the special needs of individuals. For example, a child might have limited reading ability, but be very much interested in finding out more about coal mining. An "easy" library book on the subject can meet this special need. Another child might have advanced to the stage of putting together a report on a current energy issue. A readily available and up-to-date collection of newspaper clippings can be of great help to this child.

A wide selection of materials allows children to work independently or in small groups, either to complete projects suggested with the SEEDS program or perhaps to carry out their own investigations on matters of particular regional interest. An abundance of available material also helps children to develop the valuable habit of consulting a variety of sources.

Printed materials that would be particularly useful to the children in connection with Levels 1—6 of the SEEDS program include:

1. One or more sets of encyclopedias, preferably well-illustrated and intended for children.
2. Nonfiction, science-oriented books written for children.
3. Atlases and maps.
4. Dictionaries.
5. National almanacs; world almanacs.
6. Leaflets, pamphlets, bulletins, brochures, calendars, charts, posters—often found as free or inexpensive materials from museums, historical societies, conservation organizations, commercial companies and so on.
7. Pictures, photographs, postcards.
8. Children's magazines (some adult-level magazines may also be suitable as reference for Levels 4—6).
9. Relevant newspaper clippings—may be more suitable for Levels 4—6.
10. Locally produced materials—reports on use of energy in your community, guides to wildlife identification in local parks, local histories, and so on.

If you have access to a large central library, you might take out a number of books relating to particular subjects in the SEEDS program. Many communities also have traveling libraries. With advance planning, a selection of appropriate books could be on hand when needed. Sometimes books and other materials can be borrowed from Departments of Education.

A teacher who develops a "collector's eye" can, in the course of everyday life, amass an amazing amount of free and inexpensive printed material suitable for use in the classroom. Children, particularly at Levels 4—6, can assist in finding and organizing such material. For example, they could write letters requesting free government publications, booklets published by various industries, and so on. With teacher guidance they could also

develop an efficient filing system for the collected material.

The following are a few suggestions for the use of supplementary printed materials with the children.

1. Select books and other materials with care. Try to make sure that they give accurate information. If discrepancies arise between books, take advantage of the situation to point out that it is wise to evaluate sources carefully and consult a variety of sources whenever possible.

2. Whenever possible, use reading materials after the children have had firsthand experience. For example, after the children have observed for themselves how wind energy disperses seeds, they may wish to find out more about the subject by reading.

3. Generally, have the children read with specific purposes in mind. Help them to be selective, recording and reporting only the information that is appropriate to their particular investigation or project.

4. Show the children how to use tables of contents, indexes, glossaries, and other reference tools.

Audio-visual Materials for SEEDS 1—6

Eight sound filmstrips accompany the print materials for SEEDS levels 1 through 6; four for levels 1—3 and four more for levels 4—6. Each group of four includes a concept framework or "overview" filmstrip and a level-specific strip for each of three grade levels.

These filmstrips were developed as an integral part of the SEEDS program: the core ideas in the print materials are also presented and developed in the filmstrips.

Because each concept framework filmstrip is intended for use with three different grade levels, there is a planned repetition and overlap of concepts from this strip to each level-specific strip. This repetition is an important part of the spiral pattern of concept development. A given concept is presented in its simplest form in the concept framework filmstrip, then elaborated upon or presented in its broader context in the level-specific filmstrips as content requires.

In some instances, a short sequence from a filmstrip may also serve to introduce or review a topic. In either case, these situations have been underwritten in the teacher's guides with information about the specific frames to be used.

The visuals in all eight filmstrips are predominantly photographic, to heighten the "real-life" applicability of the topics being presented. When the content of a frame was as specific as a girl using a bicycle generator to light the headlight for her bicycle (frame 11 in **Energy: How We Change It**), a photograph was specially commissioned. Other photographs were selected from a variety of stock collections on the basis of content suitability and visual quality.

When photographs were not available, for example, of a prehistoric swamp; of the strata beneath the earth's surface showing the location of coal, oil, or natural gas; or of the understructure of an offshore drilling rig, drawings were prepared. Drawings were also used to depict the energy sources and energy uses of people living a hundred years ago. These particular drawings help to reinforce the distinction between the world as children experience it and as it can be photographed and the world of yesterday.

What follows is a brief explanation of the content and applications for each series of four filmstrips; what they are about, and where and how they can best be used.

SEEDS 1, 2, and 3

In the filmstrips for Levels 1—3, the emphasis is on the energy we depend on all the time. The basic concepts are: our personal energy and where we get it; the difference between our energy needs and the energy needs of machines; renewable and nonrenewable energy sources; and the ways in which we can learn to save energy and use it wisely.

Concept Framework Filmstrip
Energy Everywhere

This filmstrip introduces the concepts developed in these three levels. It is used at the end of Level 1 to reinforce the learning that has taken place, and at the beginning of Levels 2 and 3 to review the concepts developed in the earlier grades.

Level 1

Activity 6
Food Energy or Gasoline Energy?
• frames 1–24 from **Energy Every Day** review and reinforce concepts presented in the first five activities

Activity 14
Energy Flow Through Food Chains
• frames 25–36 from **Energy Every Day** review food chains and the interdependencies that exist within them

Activity 20
What Have You Learned About Energy
• entire concept framework filmstrip **Energy Everywhere** used to help students formulate their answers to this question

Level 2

Activity 1
Energy: What Is It? Where Can We Find It?
• concept framework filmstrip **Energy Everywhere** used to summarize concepts presented in Level 1

Note: Frame references in the following activities refer to the level-specific filmstrip for Level 2, **Energy from Wind, Water, and Wood**

Activity 3
Can Energy Be Renewed?
• frames 1–19 introduce wind, water and wood as sources of energy

Activity 5
Using Wind Energy
• frames 20–24 review concept of the wind cycle and wind as a source of energy

Activity 7
Using Energy from Moving Water
• frames 25–32 review the water cycle and water as a source of energy; the dependence of wind and water cycles on the sun; wind and water as renewable energy sources

Activity 11
Using Wood Energy Wisely
• frames 33–37 review concepts of energy from wood presented in Activities 9 and 10

Activity 15
What Have You Learned About Energy
• entire filmstrip reviews topics developed in this unit

Level 3

Activity 1
Energy Everywhere
• concept framework filmstrip used as per Activity 1 in Level 2

Note: Frame references in the following activities refer to the level-specific filmstrip for Level 3, **Energy from Fossil Fuels**

Activity 7
Getting Fossil Fuels Ready for Use
• frames 25–32 explain methods used to transport coal, oil, and natural gas from sources to places in which they are used

Activity 8
Fossil Fuels and the Environment
• frames 19–24 discuss fossil fuels and the impact the methods of extraction from the ground have on the environment

Activity 10
Fossil Fuels are Nonrenewable
• frames 1–10 review renewable energy sources and distinguish between renewables and nonrenewables

Activity 11
Use Fossil Fuels Wisely
• frames 34–41 discuss ways in which we can use energy wisely

Activity 15
What Have you Learned about Fossil Fuels?
• entire level-specific filmstrip used as per Activity 15, Level 2

SEEDS 4, 5, and 6

The filmstrips for Levels 4—6 examine the many sources of energy available today. The basic concepts presented are: what energy is; the energy sources we use; the environmental and societal problems that the extraction, conversion, and use of these energy sources can cause; the advantages and disadvantages of renewable and nonrenewable energy sources; and the ways in which we can learn to use energy wisely.

Concept Framework Filmstrip Energy: The Sun

This filmstrip introduces the concepts developed in these three levels. It is used several times throughout Level 4 to introduce topics or reinforce learning that has taken place. It is also used at the beginning of Levels 5 and 6 to review the concepts developed in earlier grades.

Level 4

Activity 2 Sources of Energy
• concept framework **Energy: The Sun** used to introduce students to the source of energy we use the most

Activity 6 Web of Life
• frames 30–35 of level-specific strip **Energy: How We Get It** introduce the concept of the interdependence of elements within our natural environment

Activity 8 Energy from Water
• frames 19–24 from concept framework introduce the water cycle and the role the sun plays in it

Activity 9 Energy from Wind
• frames 15–19 from concept framework introduce the wind cycle and concept that energy from wind can also be harnessed

Activity 12 Oil: Getting it out of the Ground
• frames 13–20 from level-specific strip introduce methods used to extract oil from the ground

Activity 14 Coal: Getting It out of the Ground
• frames 21–25 from level-specific strip introduce underground and strip mining, the methods used to extract coal

Activity 18
Energy: How We Get It
• entire level-specific strip used as per final activity in Level 3

Level 5

Activity 1
Energy: Its Many Forms
• concept framework **Energy: The Sun** used to summarize concepts presented in Level 4

Note: Frame references in the following activities refer to the level-specific filmstrip for Level 5, **Energy: How We Change It.**

Activity 4
Waterwheels, Windmills, and Turbines
• frames 1–12 introduce the concept of harnessing the energy from water and wind

Activity 5
From Coal to Kilowatts
• frames 15–21 review the process by which heat energy produced by burning coal, oil, or natural gas can be converted to electricity

Activity 12
Oil Refining and Our Environment
• frames 22–31 introduce concept that although electricity is a clean energy source to use, its production methods can create polluted environments

Activity 14
Oil: The Amount We Use
• frames 36–44 review concept that although we depend on energy converted from fossil fuels we must try to use these fossil fuels more wisely, to convert them more efficiently, in ways that maintain our environment

Activity 18
Energy: How We Change It
• entire level-specific strip used as per final activity in Levels 2, 3, and 4

Level 6

Activity 1 Energy: Its Uses
• concept framework strip **Energy: The Sun** used as per Activity 1 in Level 5

Note: Frame references in the following activities refer to the level-specific filmstrip for Level 6, **Energy: How We Use It.**

Activity 7
Waste Not—Want Not
• frames 7–25 summarize the differences in the lifestyle of people a hundred years ago and the lifestyle we enjoy today

Activity 11
We Should, But Will We?
• frames 26–55 review topics discussed thus far as well as introduce topics that follow

Activity 19
Energy How We Use It
• entire level-specific strip used as per final activity in Levels 2, 3, 4, and 5.

Choosing Supplementary Audio-visual Materials

The SEEDS program offers a filmstrip for each level, and also concept framework filmstrips covering Levels 1—3 and Levels 4—6. Other useful filmstrips, as well as slide presentations and motion pictures, are available from a variety of sources. However, these do need to be carefully chosen if they are to achieve the desired objectives. They should be appropriate to the ages of the children. This is particularly important at the primary levels. Any supplementary audio-visuals should also be accurate and should present sufficient data for the development of concepts. There should be a balanced presentation of data and viewpoints. One should watch this particularly with audio-visuals produced by special-interest groups such as commercial companies or advocates of very different alternative lifestyles.

If you have specialized knowledge in a particular area or access to special equipment or settings, you may wish to consider making some audio-visuals of your own. For example, if you are able to visit a site where oil sands are being mined, you might wish to make a slide presentation or filmstrip of the process. Other teachers in your school may have personal slide collections or movie films that could prove useful. Children themselves may be able to participate in photography and film-making, particularly at Levels 4—6.

Using Audio-visual Materials

The following are some general guidelines for the use of filmstrips and other audio-visuals with the SEEDS program:

1. Always store filmstrips at room temperature. If filmstrips are used when they are hot, they will stretch. If they are cold, they will become brittle and break.

2. Always preview the audio-visual before using it with the class. You might do this alone, with other teachers, or perhaps with a small committee of children. Plan how the audio-visual will be used, referring to the film guide if there is one.

3. Prepare the class. Discuss with them the reasons for seeing the film. Give them some main points to watch for, helping the children to separate the important from the unimportant. Present any difficult vocabulary used in the film if you feel this is necessary. List any questions that the children would like to have answered through the viewing of the film.

4. After the children have seen the film, discuss it with them to see what they have learned from it. Discuss whether the film answered the questions that the children posed beforehand.

5. Do not expect too much from one showing of a film. At least two showings of a particular film are often advisable. As occasionally suggested in the SEEDS Teacher's Guides, you may wish to show the film without the sound the second time. This will allow you and the children to discuss the film as it progresses. It can also be a technique for evaluating learning if you ask questions or have the children supply the commentary.

6. In order to involve the children even more, you might like to have them record, in groups, their own version of the audio portion of filmstrips. In relation to the SEEDS filmstrips in particular, you might like to have them emphasize what they and the community could do to combat waste, pollution, and environmental damage.

7. Sometimes a follow-up activity may be appropriate. This might take the form of a written or oral report, creative writing, research, preparation of pictures or charts, role-playing, or dramatization.